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THE EFFICIENCY OF SOME PROTECTIVE ADAPTATIONS IN SECURING INSECTS FROM BIRDS.

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DURING the past four years I have been studying the food habits of birds in the *Biological Survey* of the U. S. Department of Agriculture. Owing to the extreme kindness of my chief, Dr. C. Hart Merriam, I have now at my disposal data accumulated from the examination of the stomach contents of fifteen thousand birds. My colleague, Professor F. E. L. Beal, has given me invaluable assistance in the preparation of this paper. I am also indebted for criticism to Drs. L. O. Howard and Chas. Wardell Stiles. Messrs. Schwarz, Banks, Chittenden, and Pratt, of the Department of Agriculture, have been most kind in identifying insects.

The bulk of the insect food of birds consists of grasshoppers (Acrididæ and Locustidæ), noctuid larvæ, weevils, smaller carabids, May beetles and their allies, smaller dung beetles (Onthophagus, Hister, Atænius, and Aphodius), chrysomelids, true bugs (Heteroptera), parasitic Hymenoptera (mostly Ichneumonidæ), ants, and spiders.[1]

[1] Included thus for convenience.

Protective devices of insects do not always baffle birds, and to illustrate this I have arranged my results in the following manner:

A. Restricted Protective Coloration (Resemblance to Substratum).

I. ORTHOPTERA.

1. Grasshoppers (Locustidæ and Acrididæ), 300 species of birds.
2. Katydids (Locustidæ), brown thrasher, chippy, screech owl, great horned owl, Mississippi kite, red-shouldered hawk.
3. Walking Sticks (Diapheromera), crow blackbird, two species of cuckoos.

II. LEPIDOPTERA.

1. Measuring Worms (Geometridæ), catbird, house wren, two species of cuckoos, scarlet tanager, red-winged blackbird, cowbird, bobolink, Baltimore oriole, purple finch, indigo bird, Wilson's thrush, cedar bird, white-winged crossbill, chippy, kingbird, and other flycatchers, vireos, Carolina titmouse, and many warblers.
2. Ground-colored Cutworms (Noctuidæ), practically all insectivorous birds which feed upon the ground to any extent.
3. Longitudinally striped Caterpillars:
   (*a*) Army worm, red-headed woodpecker, flicker, and other woodpeckers, cowbird, most blackbirds, orioles, meadow lark, bobolink, English sparrow, many native sparrows, kingbird, phœbe, quail, robin, bluebird.
4. Green Caterpillars:
   (*a*) Sphinxes, catbird, blue jay, two cuckoos, white-eyed vireo, red-shouldered hawk, broad-winged hawk.
   (*b*) Ailanthus Worm, yellow-throated vireo.
   (*c*) Cabbage Worm (Pieris), chippy, robin.
   (*d*) *Telea polyphemus*, broad-winged hawk.
5. Small protectively colored moths, several species of sparrows.

III. COLEOPTERA.

1. Protectively colored Longicorns (Cerambycidæ), many woodpeckers.
   (*a*) Monohammus, great-crested flycatcher.
2. Weevils, all insectivorous birds.
3. Chlamys (Chrysomelidæ), robin, bluebird, native sparrows.

IV. HEMIPTERA.

1. Jassidæ, marsh wren, house wren, cowbird, blackbirds, great-crested flycatcher, kingbird.
2. Membracidæ, great-crested flycatcher, Brewer's blackbird.

3. Scale Insects (Coccidæ), cedar bird, woodpeckers, white-breasted nuthatch, chickadee, California bush tit.
4. *Nezara hilaris*, or Brochymena, Podisus, or Euschistus, catbird, brown thrasher, house wren, cardinal, cuckoos, blackbirds, kingbird, phœbe, great-crested flycatcher, vireos, hermit thrush, blue jay, robin, Acadian flycatcher, least flycatcher, crow, cowbird, white-bellied swallow.
5. Flat Bugs (Aradidæ), downy woodpecker.
6. *Piesma cinerea*, chickadee, white-breasted nuthatch.
7. Thread-legged Bugs (Emesidæ), golden-cheeked warbler.

V. DIPTERA (Crane Flies [Tipulidæ]), many insectivorous birds.

VI. TRICHOPTERA (Larval Caddice Flies), red-winged blackbird.

VII. ARACHNIDA.

1. Spiders (Araneida), general resemblance to substratum, practically all land birds.
2. Harvest Spiders (Phalangidæ), many birds, especially catbird, wrens, and cuckoos.

B. Special Devices — Hairs.

I. LEPIDOPTERA (LARVÆ).

1. Arctiids, robin, bluebird, catbird, sparrow hawk, cuckoos, and shrikes.
2. Gypsy Moth, blue jay, robin, chickadee, chippy, vireos, cuckoos, Baltimore oriole.
3. *Vanessa antiopa*, Baltimore oriole, cuckoos.

C. Special Devices — Stings or Poisonous Bites.

I. HYMENOPTERA.

1. Bombus, or Xylocopa, bluebird, blue jay, olive-sided flycatcher, great-crested flycatcher.
2. Honey-bee (*Apis mellifica*), wood pewee, phœbe, olive-sided flycatcher, kingbird.
3. Andrena, or Halictus, red-eyed vireo, least flycatcher, great-crested flycatcher, wood pewee, olive-sided flycatcher, kingbird, blue jay, swift, cliff swallow, white-bellied swallow, humming bird, chestnut-sided warbler, Maryland yellowthroat, blue jay.
4. Scoliids (especially Tiphia, Myzine, and Elis), English sparrow, least flycatcher, kingbird, wood pewee, cliff swallow, rough-winged swallow, barn swallow.
5. Vespa, or Polistes, red-bellied woodpecker, kingbird, yellow-bellied flycatcher.
6. Mutillidæ, Says's phœbe, western wood pewee.

II. ARACHNIDA.

1. Large Biting Spiders, many birds.
2. Scorpion, screech owl, great-horned owl, burrowing owl.

III. MYRIOPODA.

1. Lithobius and others, many birds.

D. Special Devices — Ill-Flavored, or Scented, or with Irritating Qualities.

I. HYMENOPTERA.

1. Ants, most land birds.

II. HEMIPTERA.

1. Heteroptera, all insectivorous birds.
   (*a*) Anasa, broad-winged hawk, red-shouldered hawk.
   (*b*) *Prionidus cristatus*, crow.
   (*c*) Pentatomidæ, majority of insectivorous birds.
   (*d*) Hygrotrechus, song sparrow.

III. COLEOPTERA.

1. Carabidæ:
   (*a*) Smaller Carabidæ, such as Amara, Anisodactylus, Agonoderus, Pterostichus, Cratacanthus, Bembidium, and smaller Harpalus, all insectivorous birds.
   (*b*) *Harpalus caliginosus*, or *pennsylvanicus*, crow, blackbirds, meadow lark, catbird, brown thrasher, robin, kingbird, Cassin's kingbird, dickcissel.
   (*c*) Carabus, bluebird and crow, crow blackbird.
   (*d*) Cychrus, crow blackbird.
   (*e*) *Galerita janus*, bluebird, blue jay, young crow blackbirds.
   (*f*) Chlænius, crow, crow blackbird, catbird, bluebird.
   (*g*) *Calosoma scrutator*, or *calidum*, crow, crow blackbird, red-headed woodpecker, blue jay, cuckoo.
2. Histeridæ and Scarabæidæ Laparosticti (Aphodius, Atænius Onthophagus, Canthon) (foul from food), most insectivorous birds.
3. Silphidæ (Silpha or Necrophorus), crow, loggerhead shrike, kingbird.
4. Some Tenebrionidæ:
   (*a*) Nyctobates, catbird.
5. Coccinellidæ, flycatcher, red-eyed vireo, song sparrow, marsh wren, Lewis's woodpecker.
6. Chrysomelidæ:
   (*a*) Potato Beetle (*Doryphora 10-lineata*), wood thrush, rose-breasted grosbeak, quail, crow, cuckoo, catbird.

(*b*) *Diabrotica 12-punctata*, Attwater's grouse, blue jay, catbird, red-eyed vireo, cliff swallow, brown thrasher, purple martin, phœbe, yellow-bellied flycatcher.

(*c*) *Galerucella luteola*, phœbe, cedar bird.

7. Lampyridæ (Chauliognathus), see warning coloration.

IV. NEUROPTERA.

1. Chrysopa, great-crested flycatcher, song sparrow.

V. ARACHNIDA.

1. Harvest Spiders (Phalangidæ), many birds.

VI. MYRIOPODA.

1. Millipedes, many birds.

E. Warning Coloration.

I. LEPIDOPTERA.

1. Orgyia, larval, two species of cuckoos.
2. *Datana ministra* larval, two species of cuckoos.
3. *Anisota senatoria* larval, two species of cuckoos and robin.
4. Isabella caterpillar, loggerhead shrike, robin, sparrow hawk.
5. Showy butterflies, catbird, kingbird, wood pewee, purple martin, scarlet tanager, crow blackbird, cuckoo, English sparrow, song sparrow.

II. HYMENOPTERA.

1. Agapostemon and other metallic green small bees, flycatchers, humming bird, and a dozen other species.
2. Chrysis, many birds.
3. *Vespa maculata*, yellow-bellied flycatcher.
4. *Vespa germanica*, kingbird.
5. Elis and Myzine, see under stinging insects.
6. *Tremex columba*, blue jay, olive-sided flycatcher, loggerhead shrike, red-eyed vireo, night hawk.

III. COLEOPTERA.

1. Carabidæ:
   (*a*) Calosoma, Chlænius, Pterostichus, see under irritating fluids.
   (*b*) *Lebia grandis*, kingbird.
2. Lampyridæ:
   (*a*) Chauliognathus, kingbird, wood pewee, phœbe, cliff swallow, catbird.
3. Scarabæidæ:
   (*a*) *Allorhina nitida*, blackbirds, crow, catbird, blue jay, red-headed woodpecker.

(*b*) *Euphoria fulgida*, blackbirds, crow, blue jay, kingbird.
(*c*) Godsmith Beetle (*Cotalpa lanigera*), blue jay, yellow-billed cuckoo, purple martin.
(*d*) *Pelidnota punctata*, blue jay.
(*e*) *Phanæus carnifex*, blackbirds, crow, catbird, brown thrasher, great-crested flycatcher.
(*f*) *Bolbocerus farctus*, kingbird, catbird.

4. Chrysomelidæ:
   (*a*) *Systena tæniata*, song sparrow, chippy, yellow-winged sparrow, field sparrow, Maryland yellowthroat.
   (*b*) *Odontota dorsalis*, catbird, great-crested flycatcher, robin, orchard oriole, Baltimore oriole, Carolina wren, song sparrow, chippy, chewink, cardinal, cedar bird, yellow warbler, wood pewee.
   (*c*) Small metallic green beetles (especially Chætocnema, Crepidodera, Dibolia, Donacia, Graphops), a great many birds.
   (*d*) Doryphora, Diabrotica, see ill-flavored insects.
   (*e*) *Chrysomela pulchra*, kingbird.
   (*f*) *Lema trilineata*, phœbe, least flycatcher, Acadian flycatcher.
   (*g*) *Lina scripta*, cuckoo.
   (*h*) *Crioceris asparagi*, kingbird.
   (*i*) *Gastroidea polygoni*, crow blackbird, catbird.
   (*j*) *Coptocycla signifera*, crow blackbird.
5. Cerambycidae:
   (*a*) Anthophylax, kingbird.
   (*b*) *Neoclytus caprea*, catbird.
6. Malachiidæ (*Collops quadrimaculatus*), phœbe.
7. Nitidulidæ (*Ips fasciatus*), white-bellied swallow.
8. Buprestidæ (metallic colored), red-bellied woodpecker, great-crested fly-catcher, black-billed cuckoo, cardinal.
9. Cucujidæ (*Cucujus cavipes*), great-crested flycatcher.
10. Coccinelidæ, see under ill-flavored insects.
11. Silphidæ (Necrophorus), see under ill-flavored insects.
12. Byrrhidæ, robin, bluebird, native sparrows.
13. Tiger Beetles (Cicindelidæ), metallic colored, quite a number of birds.

IV. DIPTERA (METALLIC COLORED), catbird, swallows, flycatchers, etc.

V. ODONATA (BLUE AGRION), green heron.

VI. ARANEIDA (ARGIOPE), dickcissel.

F. Protective Mimicry.

I. HYMENOPTERA (RESEMBLANCE AT LEAST).
   1. ICHNEUMONIDÆ, most birds.
   2. Siricidæ, see under warning coloration.
   3. Chrysidæ, mimic Stinging Bees, many birds.

II. DIPTERA.
   1. Syrphus Fly, mimics a Yellow Jacket, most flycatchers.
   2. Drone Fly, mimics a Honey-bee, kingbird, phœbe.

III. TRICHOPTERA.
   1. Caddice Flies, said to mimic Millers, many birds.

IV. COLEOPTERA.
   1. Casnonia (Carabid), mimics an Ant, house wren, song sparrow.
   2. Some Cerambycidæ, mimic Wasps:
      (*a*) Typocerus, blue jay, wood pewee.
      (*b*) *Leptura zebra*, red-eyed vireo, kingbird.
      (*c*) Cyllene, wood pewee.
      (*d*) *Neoclytus erythrocephalus*, song sparrow.
      (*e*) *Strangalia luteicornis*, kingbird.
   3. Staphylinidæ, mimic Wasps, many birds.

The above tabulated matter is merely a collection of records, fragmentary and incomplete. It does not show the frequency with which any species of insect is selected for food by any particular bird, and consequently is liable to erroneous interpretation.

Insects which resemble the Substratum upon which they rest.

We will first proceed to ascertain whether those insects which exhibit protective coloration in its restrictive sense, that is, those that resemble what they rest upon, always baffle birds. We wish to determine how efficient this protective adaptation is; in a word, we desire to measure its working force.

In *Natural Selection*, p. 63, Wallace says: "The whole order of Orthoptera, *i.e.*, grasshoppers, locusts, crickets, etc., are protected by their colors, harmonizing with that of the vegetation or the soil on which they live." . . . On the next page he goes on to state: "We do not adduce any more examples to show how important are the details of form and

of coloring in animals, and that their very existence may often depend upon their being by these means concealed from their enemies." I am surprised to find that grasshoppers (Acrididæ and Locustidæ) in spite of their protective coloration are eaten by over three hundred species of birds in the United States.

Grasshoppers are eaten in large quantities by birds. They amount during the year, exclusive of the winter months, to 19 per cent of the volume of the insect food in the catbird, 25 per cent in the house wren, and 40 per cent in the meadow lark. In August 67 per cent of the red-winged blackbird's food consists of grasshoppers, and for the same month this staple amounts to 70 per cent in the meadow lark. For the two months of May and June grasshoppers amount to 80 per cent of the insect food of the loggerhead shrike. Of course, in the tropics, where we have such marvelous special adaptations as are found in the Mantidæ and leaf insects, there must be the most wonderful efficiency.

It may be argued that many of the grasshoppers eaten belong to the less protected forms, but we know that *Dissosteira carolina*, which is practically invisible on the ground, is selected, and that it is no uncommon thing to find the remains of several Locustidæ in stomachs. Whether these insects were taken when they were at rest, that is, when protective coloration is effective, is the great point and, so far as I have experimented with several birds, there seems every reason to believe that Acrididæ at least do not, when at rest, successfully baffle birds. I put several admirably protected grasshoppers (Acrididæ) among the fallen brown oak leaves, where I found them with the greatest difficulty, in a cage with a song sparrow, a junco, and white-throated sparrows. The legs of the insects had been pulled off, so they kept perfectly still, but the birds instantly saw and seized the grasshoppers. I tried the same experiment in a large cage with mocking birds and got the same results.

The great bulk of grasshoppers eaten by birds are Acrididæ, but stomachs containing a dozen Locustidæ are not at all uncommon. The Locustidæ most commonly selected belong to the genera Scudderia, Orchelimum, and Xiphidium. Of

the more especially protected Locustidæ we have the leaf-resembling katydids eaten by a number of birds of prey, and there are three cases on record of crow blackbirds eating full-grown walking-sticks (Diapheromera).

If we consider the number of grasshoppers (Melanopus) eaten by individual birds, it is interesting to note that the jaws and other remains of 48 grasshoppers were found in the digestive organs of one wood duck, 59 in a robin, and in a Swainson's hawk 133. These figures come from Professor Aughey, who made a study of the effect of birds upon an invasion of *Melanopus spretus*. Of course these insects were at the time so much in excess of all other species that it is only natural that they should have been taken for food. The same line of argument is applicable in the eastern United States during August and September, when many birds are subsisting to a large extent upon the abundant supply of orthopterous food. However this may be, it is a fact that in June and July, when there is no such superabundance of Orthoptera, birds nevertheless select principally from this order of insects to secure food to rear their young upon. I have no data to offer which will show how often any given grasshopper is passed over by a bird, and thus protected by its coloration being in conformity with its surroundings. I know full well that if these insects were colored a flaming red they would be much more conspicuous to us, and probably to the birds. From the little field work that I have been able to do, it seems to me probable that most grasshoppers are captured by birds not on the wing, but at rest or when moving very sluggishly. This summer, while collecting in a hayfield, I found it difficult to secure specimens of *Melanopus femur-rubrum*, which was very abundant. The insects arose at every step or so, but the instant they settled they became almost invisible. Protective coloration commenced to act as soon as they alighted. I watched an orchard oriole hunting in this field, but I failed to see any insects fly before her, though she at the time was feeding three young almost exclusively upon grasshoppers. From the little that I could see of a yellow-winged sparrow which was also feeding young, I was unable to see her flush

grasshoppers. This negative evidence is of little use. I had hoped to be able to make extended observations and perform a large series of experiments with caged birds, but have been unable to do so, and now can only offer a fragmentary contribution to this most interesting subject. Orthoptera along the Atlantic seaboard, in spite of their protective coloration, are fed upon extensively by practically all of our birds, and the degree of efficiency of their protective adaptation is probably low as compared with that enjoyed by many other insects.

The stomachs sent in to the Department of Agriculture are not accompanied with data as to the available supply of insect food. This material shows a much greater consumption of grasshoppers than I was able to find in stomachs which I collected in fields where grasshoppers were not up to their usual abundance. Although nestling birds were being reared largely upon grasshoppers, the parent birds were feeding upon insects which were less common than the grasshoppers.

Of the larvæ of Lepidoptera, the twig-resembling Geometridæ, which show a marvelous degree of special protective resemblance, are eaten by more than a score of birds of the eastern United States. The ground-colored cutworms, that so closely simulate the earth in which they live, are eaten by practically all the land birds which feed to any extent upon the ground. In the middle of May, 1898, I found that birds were feeding extensively upon Agrotis. The larvæ were abundant in the earth or under stones, but I saw none crawling about. Because of their nocturnal habits and protective coloration it is difficult to understand how the birds secured so many of them. During June and July, 1898, on a certain farm, I was unable to collect many specimens of noctuids and other protectively colored smooth caterpillars, but the birds seemed to have no trouble in finding them. Later in the season, however, during an infestation of *Protoparce carolina* in a tobacco field, no birds were found to select these protectively colored larvæ. Adult Lepidoptera as compared with the larvæ can hardly be considered as forming any significant part of bird food. The smaller inconspicuous moths seem to be relished by caged birds. These insects are occasionally preyed upon by the

majority of land birds. I have collected scores of birds in places where noctuid, crambid, pyralid, and geometrid moths were abundant, and not found a trace of a moth in any of the birds' stomachs. These insects, whether protected by their harmonizing coloration or by some other adaptation, are more immune from the attacks of birds than grasshoppers.

Weevils have a combination of protective devices; they are very hard-shelled, and they resemble either little stones or clods of earth. Moreover, they drop to the ground and feign death. Authors have dilated at length upon these admirable protective devices of weevils. But it seems to me that here we find the working force of protective adaptations at about as low an ebb as anywhere, for not only are these insects not immune, but they are eaten in great numbers by all insectivorous birds whose food we know anything about. It is not uncommon to find in the stomachs of such granivorous birds as sparrows as many as a dozen weevils.

32 Balaninus from downy woodpecker.
40 Sitones from crow blackbird.
109 *Dorytomus mucidus* from a hairy woodpecker.

The question with these weevils, as with grasshoppers, is whether they are caught while they are still and protective coloration is acting. I think that any one who has observed English sparrows and blackbirds hunting weevils on lawns can certify that many weevils are picked up from the vegetation or ground. Of course with flycatchers the case is often different, and the insects are taken on the wing. Experiments with caged birds should be carried on on a large scale. I confess that I have only experimented with one kind of bird and one kind of weevil. I sunk *Sitones hispidulus* in sand of its own color, so that only the back of the insect was uncovered. I could not see it, but the insect was seen as readily by my song sparrow as if it had been flaming red, white, and blue. In the dozen times this experiment was repeated the bird flew instantly and seized and swallowed the weevil.

I shot 45 birds on May 13 and 18, 1898, on a farm where I was only able to collect a single weevil. One-third of these birds had fed upon Sitones, Phytonomus, and Tanymecus.

One can hardly say in the face of these facts that the protective adaptations of these weevils is highly efficient in securing them from the attacks of birds. It seems as though birds became accustomed to discriminating between weevils and gravel stones, and, knowing how palatable weevils are, in spite of their hard covering, the birds seek them out, and even pass over apparently less protected insects.

In passing to the Hemiptera one finds that the homopterous division affords very little food supply to birds. The Jassids, as far as my experiments go, seem to be relished, but nevertheless they are not in large quantities habitually eaten by birds, in spite of the fact that they are very abundant. Whether it is their protective resemblance or some other device which secures them this degree of immunity from attack, I cannot say. The Aphididæ are still more protected. They are distasteful to catbirds, and, I imagine, to many other species.

Scale insects have been found only in the stomachs of several birds collected in winter, and in Baltimore orioles taken in summer. The true bugs (Heteroptera), which are protectively colored, are eaten by a great many birds.

Ground-colored spiders, whether taken while at rest or when running, are fed to the young of practically all the land birds of the eastern United States.

Hairs.

I next come to the consideration of special devices, such as, for instance, a hairy covering of the integument as we have in many caterpillars. With the exception of our two species of cuckoos no species of bird in the eastern United States, so far as I am aware, makes a business of feeding upon hairy caterpillars. The loggerhead shrike occasionally preys upon these insects, but with practically all other birds it is only in exceptional cases that a hairy caterpillar is eaten. I remember seeing an old pear tree which was infested with *Hyphantria cunea*. These insects were not at all molested, in spite of the fact that the old tree was tenanted by three broods of birds at the time — kingbirds, orchard orioles, and English sparrows.

An orchard oriole's nest with three young in another tree had a nest of hairy caterpillars within four inches of it. The hairiness of caterpillars seems to secure them from the attacks of birds more effectually than do any of the particular protective coloration devices thus far considered.

Stings.

The stings of Hymenoptera also serve as an effective protective device. A young sparrow, in whose mouth I inserted a small bee (Andrena), was stung in the throat, soon became very much affected, and finally I killed it to relieve its sufferings. A caged chewink seized a honey-bee, pecked it well and then swallowed it, but died within fifteen minutes. Mr. Benton, of the Agricultural Department, tells me that he had to give up raising ducks, because those just hatched ate honey-bees about the apiaries and were fatally stung. Nevertheless, I had a caged blue jay that would eat such large bees as Bombus and *Xylocopa virginica.* Flycatchers habitually feed upon stinging Hymenoptera, particularly upon Scoliids. The same is true of swallows, and the English sparrow is very fond of Tiphia and Myzine. Other birds occasionally take stinging Hymenoptera, less often large Apinæ. On May 18, 1898, I shot a catbird near a willow tree in which many bees were humming about the flowers, and the bird contained three small bees. The bird had a large supply of food, cutworms, beetles, etc., to choose from, but, nevertheless, took bees. It has been pointed out by Beddard that stinging Hymenoptera, in addition to being warningly colored, have disagreeable odors and tastes; it is also to be noted that many stinging Hymenoptera are not warningly colored, as the theory of protective coloration would, of necessity, demand them to be.

Among the ants there is a large division, the Myrmicidæ (the stinging ants). The smaller species of this division are eaten by a great many birds. Some of these ants have thorns on their abdomens which are said by Wallace to protect them from birds. More than any other protection perhaps is the formic acid which ants contain, but the efficiency of this device

seems low in cases where, as in the flicker, we find stomachs containing 3000 ants. The stingless ants pretend to sting, but there are many birds that they do not deceive.

There are two records of the caterpillar of the Io moth having been eaten by the yellow-billed cuckoo. In one instance no less than seven of these large stinging larvæ were taken from a single stomach.

It is plain that from my facts I interpret, not cases of protection and non-protection, but cases of greater and lesser efficiency of protective devices.

Ill-Flavored or with Irritating Qualities.

In the Heteroptera, particularly in the Pentatomidæ, we have insects emitting vile stenches. In speaking of the Pentatomidæ Comstock says: "It should not be concluded, however, that only members of this family possess this disagreeable odor; for most of the Heteroptera protect themselves by rendering their bodies unpalatable in this way. Doubtless birds soon learn this fact and leave such bugs alone." An English sparrow raised from the nest refused a Brochymena, and a song sparrow did not eat one of these insects, but ate with relish Lygus and small stinking Reduviids. In the examination of song-sparrows' stomachs I often find remains of Pentatomids, and I know of no insectivorous bird that does not eat Heteroptera. Catbirds and thrashers (caged) relish Brochymena. Blackbirds and crows frequently contain from four to ten Euschistus. The stench may protect bugs from some birds, but it certainly does not secure complete immunity from but very few birds of eastern United States. The lace-wing fly is about as nauseating an insect as I know of; yet it was greedily devoured by a caged song sparrow, and has been taken from the stomach of a great-crested flycatcher. Phalangidæ have a sickening stench, but they are eaten by many birds, particularly by house wrens and cuckoos. Millipedes come in the same category and are relished by birds.

In coming to the protective adaptations of Coleoptera we find a greater efficiency of the actual working of protective devices,

especially in the families Coccinellidæ and Chrysomelidæ. In the Coccinellidæ we have showy insects, ill-scented or flavored, that are eaten by but very few birds — the flycatchers and swallows; and hence here is a whole family which conforms well with the theory of warning coloration. Blue jays, song sparrows, thrashers, and other birds, when caged, refuse even when hungry these little beetles.

Turning to the family Chrysomelidæ, we have the potato beetle, that is refused by the catbird, blue jay, and song sparrow, and disgorged after being eaten by the thrasher. Several other examples might be mentioned, but when we come to the green Chrysomelids, especially the smaller ones, the efficiency is greatly reduced; the metallic tints that were supposed to always warn off birds are constantly disregarded, and we have many birds eating green Chrysomelids. Diabroticas are not often eaten and have been refused by song sparrows, but were greedily devoured by catbirds and thrashers. The elm leaf-beetle is almost protectively colored, but relies upon something else, perhaps its secretions, for protection. This insect is refused by many birds, but is occasionally eaten by the cedar bird. *Galerucella sagittaria* is also avoided.

The smaller Carabid beetles, whether stinking or not, seem to be eaten by practically all land birds. A song sparrow which was fed with a Chlænius was ill for twenty minutes, and then next day picked at but refused another. This same bird relished the stinking Nebria and Agonoderus. Crows, blackbirds, and jays relish *Calosoma scrutator.*

Crows and blackbirds have been known to feed Galerita, a very strong-smelling beetle, to their young. It seems incredible that birds should be able to eat Galerita, Calosoma, Carabus, and the larger Cychrus. Many birds eat species of Harpalus; the crow and the blackbirds are especially fond of *Harpalus caliginosus* and *pennsylvanicus.*

There are a score of smaller Carabidæ and Chrysomelidæ (metallicly and conspicuously colored) which are habitually eaten by birds that have an abundance of other insect food to pick from. On one farm I found fourteen species of birds preying upon *Odontata dorsalis*, and seven upon *Systena tæniata.*

With the Lampyrid beetles the stenches, whether or not coupled with conspicuous coloration, are more effective. Telephorus is occasionally eaten, but Photinus, if eaten at all, is taken only very rarely. Chauliognathus, though often so very abundant, is not eaten by many birds, but several species of flycatchers and swallows select this insect. Experiments with caged birds, catbirds, and blue jays showed that this insect was regarded unfavorably.

Warning Coloration and Mimicry.

The writers on protective coloration, especially Wallace, have stated that birds avoid insects that have metallic colors. Thus metallic coloration becomes synonymous with warning coloration. Although this is doubtless true in some cases, there are others in which it seems otherwise. The metallic beetles (Buprestidæ), certain Cicindelidæ, *Allorhina nitida*, *Euphoria fulgida*, *Cotalpa lanigera*, and Phanæus are relished by many of our common birds. And, further, it may be added that the metallic-colored flies, *Lucilia cæsar* and others, are found in large quantities in the stomachs of flycatchers and swallows; that is, in the stomachs of all birds that are swift enough to capture them. Large showy bugs colored like *Murgantia histrionica* are usually avoided by birds. A captive song sparrow refused a Murgantia, but a white-throated sparrow devoured it greedily. It is very seldom that I run across the remains of orange and black or red and black bugs during stomach examinations.

So much has been written on the subject of protective coloration of adult Lepidoptera that I cannot, even in this preliminary paper, pass over such an important chapter without stating some of the problems that here concern the student of protective coloration. I realize that in this order we have, especially in the tropics, very efficient methods of protection from birds, as has been shown by the investigations of Bates, Belt, Wallace, Triman, Poulton, and Beddard; but in the eastern United States the cases of efficient mimicry do not show up quite so well, for the reason that there are not yet any records

of birds habitually preying upon butterflies. In fact the same question has been agitated in the discussion following the reading of Mr. Dixey's most interesting paper at the London Entomological Society; and it was found that comparatively few members had ever seen birds take butterflies. In the eastern United States there have been hardly more than a dozen published records of birds seen in the act of taking butterflies. In fact birds, so far as I have observed, seem to make no practice of giving chase to the butterflies that float about them as they busily catch other insects. In fact butterflies seem to be avoided, whether they are indifferently colored, protectively colored or mimetic, or warningly colored. It is said by Wallace that our milkweed butterfly is imitated by Limenitis, which thus escapes capture; but, as none of our butterflies are persecuted, it seems strange if mimicry has actually been aimed at. Beddard has shown that there are difficulties in the theory of protective mimicry, from the fact that mimicking and mimicked forms are eaten, and that, in certain cases, instances of apparently useless mimicry occur. Beddard also shows some inconsistencies in the current interpretation of the theory of warning coloration. He shows that certain warningly colored papilio larvæ have a habit of not relying on their warning coloration, but conceal themselves. He further concludes, in speaking of warning coloration: "There are so many other easier ways of defense, and one would imagine that the action of natural selection would proceed along the line of least resistance." Some criticism in a measure adverse to protective mimicry is brought out in a paper entitled "Mimetisme," by M. C. Piepers, in the *Proceedings of the International Zoölogical Congress*, 1895, pp. 460–476. The greatest piece of work in actually putting the protective coloration theory to test has been accomplished by Frank Finn. The results of this investigation are published in the *Journal of the Asiatic Society of Bengal*, Vol. LXVI, Part II, No. 4, 1897. The author performed hundreds of experiments in feeding birds with butterflies. Mimetic, warningly colored, and non-protected butterflies were used. The birds employed included *Liothrix luteus*, *Otocompsa emerisa*,

Molpastes leucotis, M. bengalensis, Pycnontus sinensis, Cratceropus canorus, Acridotheres tristis, Anthracoceros, Mesia argentauris, Dissemurus paradiseus, Dicrurus ater, Sturna menzbieri, Kittacincla macrura, Chloropsis aurifrons, Malacias capistrata, Turnix taigoor. The experiments were made in cages and in an aviary. Mr. Finn's conclusions are:

"1. That there is a general appetite for butterflies among insectivorous birds, even though they are rarely seen, when wild, to attack them.

"2. That many, probably most species, dislike, if not intensely, at any rate in comparison with other butterflies, the warningly colored Danainæ, *Acrea violæ*, *Delias eucharis*, and *Papilio aristolochiæ*, of these the last being the most distasteful and the Danianæ the least so.

"3. That the mimics of these are at any rate relatively palatable, and that the mimicry is commonly effectual under natural conditions.

"4. That each bird has to separately acquire its experience, and well remembers what it has learned."

That, therefore, on the whole, the theory of Wallace and Bates is supported in this and my former papers, so far as they deal with birds (and with the one mammal used). Professor Poulton's suggestion that animals may be forced by hunger to eat unpalatable forms is also more than confirmed, as the unpalatable forms were commonly eaten without the stimulus of actual hunger — generally also, I may add, without signs of dislike."

Mr. Finn's elaborate series of experiments have proved that non-protectively colored butterflies are preferred to warningly colored ones. He notes the avoidance of the protected forms, but, in cases where they are eaten, fails to detect any signs of actual distaste. In fact there is, it seems to me, no hard and fast line between distaste and lack of preference. There is, however, in the mind of every one a distinct difference. For instance, I prefer beef to mutton, but this does not signify that mutton is distasteful to me. On the other hand, quinine and kerosene are actually distasteful. In applying the same standard to the case of the warningly colored butterflies I

should not, in spite of their not being preferred by birds, have called them distasteful. In my own experiments I have found that certain beetles are avoided to such an extent that birds will not touch them even when they are very hungry. Laying aside this quibble of the degree of distastefulness, it is clear that the lack of preference, however slight, is all that is required by the theory of protective coloration.

It would be exceedingly interesting to know to what extent the species of birds which Mr. Finn experimented with, feed upon butterflies when at liberty. I know of no native species of birds in the United States which habitually prey upon butterflies.

In the Linnean Society's journal, *Zoölogy*, Vol. XXVI, there is an article entitled "Natural Selection the Cause of Mimetic Resemblance and Common Warning Colours," by Professor Edward B. Poulton. The scope and aims of this masterly paper are so entirely different from those of my little contribution that I will not discuss it here. I have experimented in feeding butterflies to birds just enough to become confused. My song sparrow ate a *Papilio turnus;* a blue jay found a *Colias philodice* distasteful; while catbirds relished *Vanessa antiopa*. In spite of these experiments I must conclude, from the examination of stomach contents and field work, that butterflies are comparatively immune from the attacks of birds of the eastern United States.

Caddice flies are supposed to mimic small moths for protection, but they, nevertheless, are eaten by many birds, even when plenty of other insects are obtainable.

In the Diptera and Hymenoptera we have such swift-flying insects that birds have great difficulty in catching them. The Muscidæ are relished by most birds, but only the flycatchers and swallows are swift enough to catch them. The kingbird eats the Eristalis fly that mimics the honey-bee and also other mimicking Syrphus flies.

The parasitic Hymenoptera (Ichneumonids) are said to mimic the stinging ones, but they are eaten by many birds. It has also been supposed that many of our flower-infesting Cerambycid beetles mimic Scoliid wasps. However this may be, the

beetles are seldom eaten. A wasp-like Cerambycid *Neoclytus erythrocephalus*, however, was relished by a song sparrow. It is maintained also that Staphylinid beetles mimic stinging Hymenoptera; nevertheless, they are relished by a good many birds.

One of the most salient difficulties in the actual working of the theory of protective mimicry is met with when the insects eaten by the kingbird are examined. Here one finds that the yellow and black Hymenoptera, imitating Syrphidæ, are eaten by the kingbird. Further, that *Eristalis tenax*, which mimics the honey-bee so perfectly, is also taken. These facts, though bad enough for the effectiveness of the mimicry, are not to be mentioned in the same category with still another. The kingbird is well known to feed upon honey-bees, but, strangest of all, the bird seeks only the drones. This would lead one to infer that if a bird was keen enough to tell the different castes of bees apart on the wing, it would not be likely, to any considerable extent, to be humbugged by mimetic resemblance.

Mr. Benton, of the Department of Agriculture, tells me that domesticated fowls can tell the difference between drones and working honey-bees. Hens will stand by a hive and seize the drones as they come out, but do not touch the workers. In fact hens make a certain alarm cluck when they suddenly run across a worker.

Miscellaneous Matter.

Size often determines whether a given insect shall be eaten by a particular bird. The *Papilo turnus* which my caged song sparrow killed after several minutes of hard work would undoubtedly have escaped had it been outside, and a sphinx moth which my catbirds killed after a quarter of an hour's struggle would certainly have gotten away. So with many beetles. Small species can be easily managed; but a catbird, for instance, with a *Passalus cornutus* is helpless, while a blue jay has the strength to break the insect to pieces and then eat it. I gave a *Hydrophilus triangularis* to my blue jay. His beak glanced off the insect's back again and again, but finally he

struck it on the ventral side so as to disable the beetle, and then he hammered it to pieces and ate the soft parts.

The quick flight of Odonata and many Diptera prevent them from being captured in any quantities. I can offer no reason why the rose chafer is not a favorite article of bird food. I have often found this insect abundant where I have collected birds, but, with the exception of the kingbird, no bird seems fond of it. Catbirds captive and at liberty avoid the Colorado potato beetle. One adult catbird, however, shot where there was an abundance of food, had eaten a potato beetle. On the other hand, catbirds in captivity relish *Diabroctica 12-punctata* but avoid it when at liberty. I could give a number of other examples equally perplexing.

Conclusions.

It appears to me that certain writers upon protective adaptations have identified their specific cases as coming under the ban of the theory of protective adaptations in so far as they coincide with or do not run counter to a statement of Darwin's, in which he says that a necessary deduction from the theory of the definite facts of organic nature is that no special organ, no characteristic form or marking, no peculiarities of instinct or of habit, no relations between species or between groups of species can exist, but which must now be or once have been useful to the individuals which possess them. This statement of Darwin's has comparatively so little intention and is capable of such great extension that it forms a secure bulwark over which no armies opposed in the least degree to the theory of protective adaptations can ever hope to pass. It is as good as saying that every conceivable phase of animal life is a protective adaptation (a statement which I cannot deny). But it seems to me that there are different degrees of protective adaptations — that some are much more effective than others. There is need of some standard of the efficiency of protective adaptations, *i.e.*, a measure of their working forces. Some of the writers on the subject have led one to suppose that a good many protective devices secure almost complete immunity

from the attacks of birds; while other investigators have been tempted, when they found in particular instances that facts, apparently, did not coincide with current views, to abandon the theory entirely. Butler fully realizes the fact that very broad generalizations are almost impossible, since, as he states, there is no insect that will not be refused at some time by some birds, and there are no insects that one can be sure will not be eaten by some birds under certain conditions. Beddard, after reviewing his own experiments and those of Wallace, Butler, Weir, Morgan, Weisemann, and Poulton, states that there is the greatest difficulty in drawing broad conclusions; and he, moreover, points out the fact that, in the case of the insects that are refused, it is not usually on account of color alone, but more often for the reason of a collection of disagreeable attributes, such as spininess, conspicuous coloration, and bad flavor.

It seems to me that many caterpillars that have warning coloration are refused in part because they are hairy, because birds refuse inconspicuous hairy caterpillars as well as showy ones; and, moreover, cuckoos which feed upon hairy caterpillars do not avoid those of conspicuous pattern. Nevertheless, the hairiness of caterpillars must be ranked as highly efficient in protecting them from birds. The showy, ill-flavored Coccinellidæ may be awarded almost as high a place, and the elm-leaf beetle, not showily colored, should be rated even higher. The Diabroticas, Doryphoras, and several other similar beetles should be also reckoned as possessing comparative immunity from many birds.

Wherein lies the reason for the comparatively high scale of immunity of plant lice and rose chafers (Macrodactylus) I know not. It is a fact that the smaller Carabidæ, such as Anisodactylus, Amara, Nebria, Agonoderus, and Harpalus, are eaten much more frequently than Galerita, Carabus, and Calosoma. And from birds the size of sparrows and smaller it is doubtless true that large Carabids are well protected. Nevertheless, we know that the large insectivorous birds are not baffled by the irritating fluids these insects emit.

Among the Lampyridæ, Chauliognathus appears to have

almost as high a degree of immunity as Coccinellidæ. The quick-flying Diptera seem to be not far behind in the scale of immunity from the attacks of birds, but with aculeate Hymenoptera there is somewhat of a drop, and when we get to the parasitic Hymenoptera we find that they are eaten by many birds and apparently relished.

Among the Coleoptera, Cyllene and other conspicuous flower-loving Cerambycids are seldom found by the examiner of birds' stomachs. Meloids of the type Epicauta have, in their secretions, an efficient protection against birds, but they are exceptions. Thus, in each of five kingbirds' stomachs, taken in one locality, there were thirteen of these beetles. Butterflies, in the scale of efficiency of their protection, will rank a good deal higher than even Coccinellidæ. Homoptera, with the exception of Cicadas and Jassids, are seldom eaten. Dragon-flies are not often caught when they have once been safely launched on the wing, but May flies and Caddice flies are terribly persecuted.

Apparently irrespective of coloration, the smaller Carabidæ, and particularly all abundant Scarabæidæ, except the rose chafer, are eagerly sought after for food by most insectivorous birds.

From the study of the insectivorous food of birds, it seems to me that biologists have not yet entirely elucidated all the details of the nature of the adaptations of insects which are most potently protective. Some investigators seem to reason from the standpoint of man: that since an insect tastes bad in our mouth, therefore it must be distasteful to a bird. What is one man's meat may be another man's poison. Consequently it seems to me that the human criteria are not necessarily adapted to suit the avian case. It does not follow that, since a stink bug nauseates our stomach and irritates our tongue, it will produce a like effect on a crow. Hence there appears to be need of a little more avian psychology before it is possible to entirely coincide with certain current views upon protective adaptations.

Numerous species of bugs and beetles which, in addition to being protectively colored, possess ill-smelling, bad-tasting, and

irritating secretions, would naturally be supposed by some writers to be avoided generally by nearly all birds, *but they are habitually eaten* by many birds of the eastern United States. This would lead one to infer that protective adaptations in our country are not always so efficient in securing insects from birds as has been commonly held.

The fact that beetles and other insects which are gaudily colored — and consequently are supposed to be protected from birds — are greedily devoured by many birds, appears to show that warning coloration is not always as efficient as alleged, and one is almost led to believe that, because of this inefficiency of warning coloration in many cases, protective mimicry has been in some instances overestimated. Even the theory of protective coloration in its restrictive sense, when pitted against some facts, apparently loses a little of its luster in certain cases; and we are forced to admit that factors may exist which sometimes nullify its action, so that the alleged protective coloration is not the all-important factor in securing an insect from extermination, as some earlier naturalists have supposed, but that there are other equally important factors that demand consideration. That is to say, coloration is not all, but only one of the determining elements.

NOTE ON THE VERTICAL DISTRIBUTION OF MALLOMONAS.

G. C. WHIPPLE AND HORATIO N. PARKER.

MALLOMONAS is a microscopic organism that is often found in the water of ponds and lakes. It usually occurs in greatest abundance in the spring and autumn, but occasionally it appears at other seasons. It is an odor-producing organism, and as such is liable to give trouble in water supplies. Its odor is similar to that of Cryptomonas, which has been described as resembling "candied violets." As the odor increases in intensity it loses its aromatic qualities and becomes "fishy." In addition to its odor it has a slight sweetish taste. Mallomonas is not known to have ever given serious trouble in a water supply, because it is seldom found in large numbers for any considerable length of time, but several cases are on record where it has been present in water supplies, and where it has undoubtedly caused a noticeable odor. Observations seem to indicate that whenever it is present in the water to the extent of about 500 per cc. its odor may be recognized. However, this paper is not concerned with the odor-producing properties of Mallomonas, nor its effect on water supplies, so much as with the organism itself, its structure, its development, and especially its peculiar, characteristic, vertical distribution in ponds and lakes.

The earliest description of Mallomonas was that of Perty in 1852. To him we owe its generic and specific names. Some writers have questioned the claim of Mallomonas to rank as an independent genus. Stein held that it was but a monad of Synura, freed from its colony. Recent observations have established the position advanced by Perty and adopted by Kent.

Kent's description of Mallomonas is as follows:

GENUS MALLOMONAS PERTY.

Animalcules free-swimming, oval or elliptic, persistent in shape; cuticular surface indurated, clothed with long, non-vibratile, hair-like setæ; a single,

long, vibratile flagellum produced from the anterior extremity; contractile vesicle indistinctly developed. Inhabiting fresh water.

M. PLOSSLII PERTY.

Body ovate or elliptical, slightly narrower anteriorly, cuticular surface finely shagreened or crenulate, thickly clothed with fine hair-like setæ, whose length is less than that of the body; flagellum long and slender, retractile; endoplasm vacuolar, amber color or greenish-yellow; contractile vesicle indistinct, posteriorly located. Length of body, 1-1000″ to 1-900″. Habitat marsh water.

This description is somewhat incomplete and does not take into account certain common variations from the type form. Examination of a large number of specimens found in the waters of Massachusetts and New York has revealed the following facts:

The length of Mallomonas varies at different times and in different localities from 20 to 60 μ. The ratio of length to width varies from 4 to 1. Sometimes the bodies are long and narrow, and sometimes they are almost spherical, resembling the Rhizopod, Actinophrys. The older forms are somewhat more spherical than the younger ones. All forms of Mallomonas are more or less spherical in end view.

The setæ or spines vary in length from 15 μ to 30 μ; the average length is about 25 μ. They have a diameter of 0.3 μ at the base and taper to a point at the fore end. They are generally straight, but, being flexible, they sometimes appear to be curved. At the base they bend sharply like a polo stick and are attached to basal plates which have a rectangular shape. It is the irregular lapping of these basal plates that produces the corrugated appearance of the cuticular surface mentioned in Kent's description. The setæ are easily broken off, and it is not uncommon to see specimens with only two or three setæ present. When the organism moves forward the setæ are directed backwards.

The color of the organism is usually green when the specimen is young and fresh, but sometimes it changes to greenish-yellow or brown. Besides the two chromatophores, a contractile vacuole and numerous oil globules may be discerned. The

nucleus, if present, is indistinct. At times a globular, balloon-like body is attached to the posterior extremity. It is apparently a development of the contractile vacuole. It is usually small and colorless, with a granular structure, but sometimes it is large, green, and spore-like. This body may be connected with some process of reproduction. Reproduction of Mallomonas takes place by sporular encystment. The protoplasm contracts, assumes a spherical shape, shrinks, and becomes invested with a thin integument. A single spore is formed by each individual. The liberated spores have a brown color and are occasionally surrounded by a gelatinous tegument.

All the forms of Mallomonas observed by the writers, notwithstanding their variations in size and shape, may be properly included under the single species *M. plosslii* Perty.

Fresenius (*Infusionsthiere*, Abth. III, 1878) described a minute form, to which the name *M. fresenii* has been given. Zacharias (*Forschungsberichte*, Theil I, s. 16) has described a species which he calls *M. acaroides* Zach. It differs from the type form only in having the setæ thicker and more curved than those of *M. plosslii* (*Vergl. zur Kenntniss kleinsten Lebensformen*, 1852, s. 83). He has also described (*Forschungsberichte*, Theil I, s. 73) a new variety which he has called *M. acaroides* Zach. var. *producta* (Seligo). It differs from the previous form by its larger size and by its longer spines. Seligo (*Ueber einige Flagellaten des Süsswasserplankton*, Jan. 3, 1893), under the name Lepidoton, has described the same form.

Mallomonas is of interest to students of aquatic life because of its peculiar vertical distribution during the summer. Three instances of this are on record; namely, in Lake Cochituate and Whitehall Pond, of the Boston supply, and in Ridgewood Reservoir, of Brooklyn, N. Y.

Lake Cochituate is a lake of almost colorless water, with a maximum depth of sixty feet and with well-marked stagnation periods. Mallomonas is often found there in numbers varying from 50 to 100 per cc. On June 24, 1896, it suddenly appeared in the lower strata of water near the gate house. There were 116 per cc. at the mid-depth thirty feet, 42 per cc. at the bottom sixty feet, but none at all at the surface. The follow-

ing week the same peculiar distribution was observed, the surface water being free from them, while the number at the mid-depth was 336 per cc. This arrangement continued until the first of September. During all this time not a single individual was observed at the surface, and the numbers at the mid-depth fluctuated between wide limits, on one day being as high as 3640 per cc. At the bottom they were invariably present, but always in much smaller numbers than at the mid-depth. The following table gives the number of Mallomonas at the surface, mid-depth, and bottom for the entire period of growth.

	Number per cc.				Number per cc.		
Date.	*Sur.*	*Mid.*	*Bot.*	*Date.*	*Sur.*	*Mid.*	*Bot.*
June 18,	0	0	0	July 28,	0	264	162
24,	0	116	42	Aug. 4,	0	3640	6
July 1,	0	336	2	11,	0	1200	10
8,	0	46		18,	0	1380	4
15,	0	724	276	25,	0	298	8
22,	0	1102	158	Sept. 1,	0	0	0

On July 17 a series of samples was taken at intervals of ten feet through the vertical, and the following results were obtained.

Depth.	Mallomonas per cc.
Surface.	0
10 ft.	0
15 ft.	2
20 ft.	1454
25 ft.	794
30 ft.	548
40 ft.	112
50 ft.	88
60 ft.	64

These figures, together with the temperature of the water at various depths, are shown by the diagram. It will be observed that the greatest numbers were found just below what may be called the thermocline. From the surface down to a depth of ten feet the temperature of the water was uniform. Between ten and twenty feet the temperature fell rapidly. The water in this stratum was not stagnant, however, as other observations — not given here — indicated. But below a depth of twenty feet

the temperature was practically constant from week to week, indicating a condition of stagnation. It was at the boundary line between the stagnant water and the slowly circulating

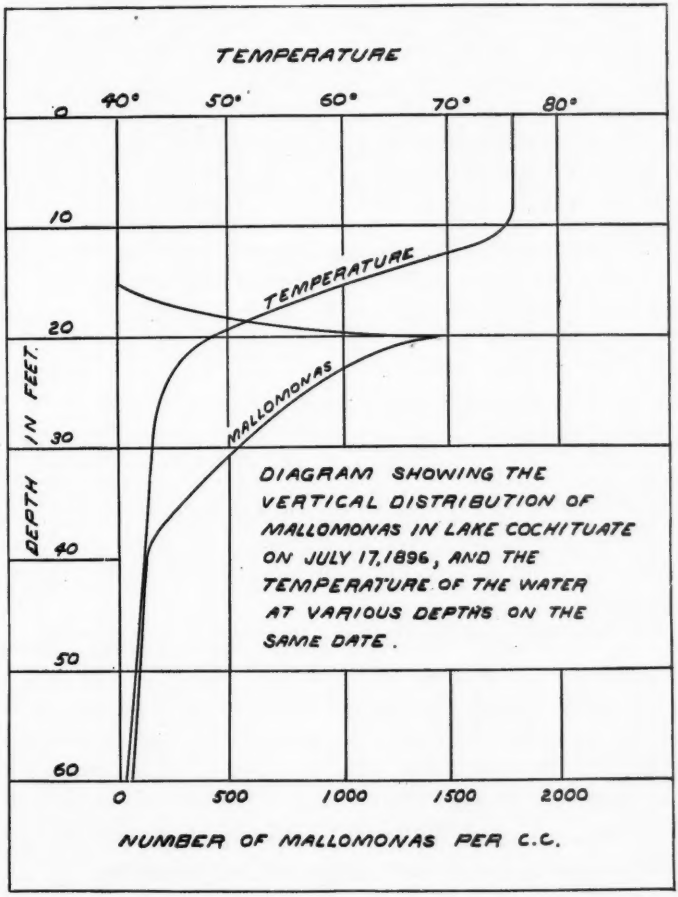

DIAGRAM SHOWING THE VERTICAL DISTRIBUTION OF MALLOMONAS IN LAKE COCHITUATE ON JULY 17, 1896, AND THE TEMPERATURE OF THE WATER AT VARIOUS DEPTHS ON THE SAME DATE.

water above it that the Mallomonas reached their greatest growths. Below this depth the numbers decreased rapidly.

A similar case of vertical distribution occurred in Whitehall Pond during the summer of 1897. This is a pond of dark

brown water, with a depth of about twenty-five feet. From May 7 to June 7 the surface samples contained a few Mallomonas. On June 14 there were 110 per cc., after which there were less than 11 per cc., until August 23 they suddenly rose to 2186 per cc. This suggested that there had been a growth at the top of the stagnation layer as in Lake Cochituate, and that a high wind had stirred the water and brought the organisms to the surface. This seemed the more probable, because the color of the surface water, which had been 0.57, rose to 0.66. On August 27, four days later, samples were taken every five feet from surface to bottom. The following results were obtained.

DEPTH.	NUMBER OF MALLOMONAS PER CC.	COLOR.
1 ft.	20	0.54
5 ft.	880	0.54
10 ft.	1936	0.57
15 ft.	84	0.64
20 ft.	40	1.06

These observations seemed to show that there had been a large growth below the thermocline, that the organisms had been scattered through the water, and that they were now sinking back toward their original position. The color readings showed that the pond had been stirred to a depth of only about fifteen feet.

On September 14 the vertical distribution was as follows.

DEPTH.	NUMBER OF MALLOMONAS PER CC.
1 ft.	0
5 ft.	0
15 ft.	10
20 ft.	432
25 ft.	472

In November, during the period of autumnal circulation, Mallomonas again appeared at the surface, the number per cc. reaching forty.

This tendency of Mallomonas to concentrate just below the thermocline was observed in Ridgewood Reservoir, Brooklyn, N. Y. In July, 1898, on the 6th inst., the water at the surface contained 60 per cc., while at the bottom (twenty feet) there

were 156 per cc. At a depth of fifteen feet they were more numerous, but the actual number per cc. was not determined. On July 14, after a high wind, the surface water contained 420 per cc.

The reasons for the peculiar vertical distribution of Mallomonas are not wholly apparent, but the reactions of the organism to light and temperature offer some suggestions.

Mallomonas possesses a strong heliotropism. This has been shown by laboratory experiment. A brass tube having glass ends was filled with water containing 3360 Mallomonas per cc., and so placed that one end was exposed to the light, while the other was covered by a black cap. After standing for forty-eight hours in a horizontal position, portions of the water were carefully withdrawn simultaneously from each end of the tube and examined. At the dark end of the tube only 810 Mallomonas per cc. were found, but at the light end there were 9480 per cc.

From this tendency to move towards the light, it would appear that the Mallomonas had tried to get as near as possible to the surface where the light was strongest, but that the warm, agitated water above the thermocline did not offer favorable conditions for growth. During the winter Mallomonas does rise to the surface, and is usually more abundant there than elsewhere in the vertical.

Apparently Mallomonas prefers to live where the light is strong, where the temperature is low, and where the water is quiet. No doubt the long setæ (and possibly the balloon-like bodies referred to above) help to keep the organisms from sinking in quiet water. These become broken off when the water is violently agitated, and after that the organisms sink more readily. This may partially explain why Mallomonas does not develop near the surface during the summer.

THE COLORS OF NORTHERN MONOCOTYLEDONOUS FLOWERS.

JOHN H. LOVELL.

In the accompanying table the 1058 species of northern monocotyledonous flowers recognized in the *Illustrated Flora of Britton and Brown* have been arranged according to their predominant colors. The territory covered extends from the Atlantic Ocean westward to the 102d meridian, and from the parallel of the southern boundary of Virginia and Kentucky northward, to include Labrador and Manitoba. The green or dull-colored flowers number 857, and the non-green 201, of which 41 are yellow, 82 white, 22 red, 22 purple, and 34 blue. Of the 28 families, 12 contain yellow flowers, 11 white, 5 red and purple, 5 blue, and 15 green. Six families are represented by only a single species. Yellow and white flowers usually occur in the same families, except in the Alismaceæ with 19 white, and the Xyridaceæ with 6 yellow species. There are described in the sixth edition of *Gray's Manual* 785 monocotyledons, which, for the purpose of comparison, I have also tabulated according to their colors; 621 have green or dull-colored flowers, and 164 non-green, divided into 38 yellow, 67 white, 19 red, 19 purple, and 21 blue. The yellow, red, and purple are less than those of the *Illustrated Flora* by 3 each, the white by 15, the blue by 13, and the green by 236. This difference is due partly to the more restricted area of the *Manual*, and partly to a different conception of varieties and species.

The flowers of the four families, Typhaceæ to Scheuchzeriaceæ, are either anemophilous as in Typha and Potamogeton, or hydrophilous as in Ruppia and Zostera, or self-fertilized as is probably the case in Triglochin and Scheuchzeria. The perianth segments are very small or wanting, and the numerous flowers are usually crowded in a greenish inconspicuous inflorescence which is often spathaceous. The spikes of Typha

are, however, brown or black, and those of Potamogeton are frequently reddish. The 19 species of the Alismaceæ all have white petals and are attractive to Syrphidæ. On the small flowers of Alisma Plantago-aquatica, Müller collected 5 flies of this genus, and on Sagittaria latifolia I have taken 11 Syrphidæ, 6 other Diptera, 2 Coleoptera, and 4 bees. In the latter species the globular mass of yellow stamens, about 40 in number, are brought into strong relief by the white petals. The primitive color of the Alismaceæ was doubtless green, the transition of which to white may be illustrated by many examples. The involucre of Cornus changes from green to white during growth; the floral leaves of *Monarda clinopodia* are white; the calyx of Polygonum in different species is green, greenish-white, and white; the upper sepal of *Habenaria obtusata* is green with whitish margins; the perianth of *Ornithogalum umbellatum* is white above and green beneath; Chrosperma (Amianthium) is white, but turns greenish with age; I have observed the marginal neutral flowers of a culture variety of Hydrangea to remain upon the plant for many months and change from white to pale green, and many small flowers vary from green to white. Of the Vallisneriaceæ Philotria and Vallisneria have white hydrophilous flowers, and Hydrocharis is entomophilous. Müller regards Vallisneria as an intermediate stage between a water-fertilized and an insect-fertilized plant.

The Gramineæ with 371, and the Cyperaceæ with 334 species include nearly two-thirds of northern monocotyledons. The same external conditions appear to have been favorable to the development and continuance of a great number of forms in both families. The flowers are wind fertilized, though they are visited occasionally by flies, bees, and beetles for pollen. The perianth is nearly suppressed and is represented only by scales or bristles. Both the glumes of the Gramineæ and the bracts of the Cyperaceæ are often reddish or purplish. This coloration is of physiological importance, according to Pick and Stahl, and by converting light-rays into heat promotes both in young leaves and the organs of flowers transpiration, metabolism, and growth. Darwin states in "Variation in Animals and

Plants under Domestication" that red wheats and red sugar canes are more hardy than white, and I have also noticed that the most vigorous variety of maize or Indian corn in my garden had purplish-red culms, glumes, and silk. The red coloring of the styles is believed to favor the growth of the pollen tubes and occurs in many flowers. Leaf variegation is found in some grasses, as in Eulalia, one beautiful variety of which has the leaves striped longitudinally with white, and in another marked transversely with yellow.

Many Araceæ are cultivated for their handsome foliage, which is marbled or striped with yellow, white, purple, and red. The capability of the leaf to produce bright coloration has determined the adaptation of the spathe for attractive purposes, and its development has been attended by the reduction or suppression of the perianth. The spathe of *Arisæma triphyllum*, Indian turnip, is variegated with purplish and white stripes, and C. M. Weed found the flowers visited by small diptera of the genus Mycetophila, or family of fungus gnats. *Symplocarpus fœtidus*, the skunk cabbage, has the spathe spotted and striped with purple and yellowish-green; the odor is repulsive, and the visitors are small active flies of the genus Phora. *Calla palustris* has a conspicuous white spathe and, according to Eu. Warming, pond snails aid in the fertilization; Delpino mentions more than 4 European species of Araceæ, which, in his opinion, are fertilized by snails. In Orontium the perfect bright yellow flowers are densely crowded over the narrow spadix, and the green spathe is distant, investing only the lower part of the scape. The investigation of the numerous tropical species of this family promises to reveal many remarkable adaptations. The Lemnaceæ are regarded as simplified Araceæ, and the minute green flowers, in the opinion of Ludwig and Müller, are adapted to insects which live upon the surface of the water.

The small yellow flowers of the Xyridaceæ, which are regular, trimerous, and solitary in the axils of scale-like bracts, are evidently primitive in type, and are probably derived directly from ancestral green forms. This transition is illustrated in Hypoxis, which has the perianth segments yellow above, but

the three outer green on the lower side; in *Nymphæa advena* the lower half of the outer sepals is green, and the upper half yellow; *Trollius laxus*, which grows in dense swamps, has greenish-yellow sepals, but the culture varieties are bright yellow, while the perianth of *Veratrum viride* is yellowish-green. Henslow thinks it probable that the yellow coloration of the petaloid structures is correlated with the yellow coloring of the anthers and pollens, universal among gymnosperms and very prevalent among angiosperms, and also extending to the anther scale of Pinus and the sporophylls of Lycopodium. Certainly yellow is the first color to be developed in many dicotyledonous families.

The 12 species of the Commelinaceæ all have blue flowers, except *Tradescantia rosea*, which is rose-colored, and the smallest northern species with narrow grass-like leaves and few flowers. Blue in this family appears to have been preceded by a reddish stage, and this view is strengthened when we remember that many blue Boraginaceæ have passed through a red stage, as Myosotis, Pulmonaria, and Echium, several species changing from red to blue during the course of individual development. The filaments of Tradescantia are bearded as in Verbascum, which is visited by pollen-collecting bees.

The original color of the Pontederiaceæ was almost certainly yellow, as it still is of the smallest species, *Heteranthera dubia*, water star grass, which has a slender stem and linear, sessile leaves. Every stage of the transition from yellow to blue is shown by *Viola tricolor*, and in Gentiana the simplest species, *G. lutea*, is yellow, but the more highly specialized species are purple-blue. The middle lobe of the upper lip of *Pontederia cordata* is marked by two yellow spots, which serve as honey guides. This is one of the handsomest as well as commonest of river plants, producing thousands of spikes of purple-blue flowers with blue anthers. The most important visitors are *Bombus vagans* and *B. borealis*, though I have also collected upon the flowers two other bees, four Lepidoptera, and four Diptera.

The Juncaceæ have a small, regular six-parted perianth which is often reddish or purplish brown. The flowers are anemo-

philous and proterogynous, though self-fertilization of open flowers and cleistogamy occur. Several European species have rather conspicuous flowers and attract insect visits.

The Melanthaceæ have regular, perfect, and, for the most part, small flowers in panicles and racemes. Many of the species grow in woodlands and swamps, secrete nectar in readily accessible positions, and are visited by Diptera, as in Tofieldia and Veratrum. The flowers exhibit but little bright coloring and are chiefly greenish-white or greenish-yellow; in Zygadenus and Melanthium there are green, greenish-yellow, and greenish-white species; in Veratrum yellowish-green and purplish. Yellow, white, and purple appear to have been developed directly from the primitive green without passing through any intermediate stage. There is a complete absence of red and blue and of variegation. The primitive color of this family and the two succeeding was undoubtedly green, resembling the wind-fertilized Juncaceæ, with which they are closely allied in structure.

The Liliaceæ have attained a much higher stage of coloration than the Melanthaceæ, and the inflorescence exhibits the most brilliant and variegated hues. The flowers are solitary or clustered, very large and conspicuous, and, in some instances, adapted to the visits of a single species of insect. They are very remarkable for their range of color and, long since, compelled botanists to lay aside the cyanic and xanthic speculations of de Candolle. The hyacinth displays every shade of yellow, white, red, and blue, and Darwin gives several instances of red and blue flowers produced on the same truss; the tulip exhibits yellow, white, red, and purple-violet; and many other genera are almost equally polychromatic. The 9 species of Allium are green, white, and rose, the development of coloring having proceeded in this order. The honey is abundant and is more accessible in the green and white species than in the rose; the inflorescence is umbelloid, and the guests are bees, Lepidoptera, and flies. Florists also offer bright yellow and blue forms. About 45 species of the genus Lilium are known, many of which are adapted to diurnal and nocturnal Lepidoptera. The entire genus is justly admired for the beauty of its flowers.

It has long been a favorite in floriculture and many varieties have been produced by hybridization. Seven species with yellow, orange-red, and scarlet flowers are indigenous to the northern states, and *L. tigrinus* is adventitious from Asia. Red flowers are peculiarly attractive to butterflies, and they are the chief agents in pollenizing many pinks and species of phlox, and, according to Müller, of Tritoma and the fiery red *L. bulbiferum*. I have repeatedly seen *L. Philadelphicum*, which is orange-red spotted with purple inside, visited by *Argynnis aphrodite*, the silver-winged butterfly, which is itself yellowish-red spotted with silver, but never by any other insect. The yellow nodding flowers of *L. Canadense* are visited only by bees, and I have seen *Bombus vagans* rest first upon the stigma and then climb the stamens to the base of the corolla. The white exotic species, such as *L. martagon* and *L. harrisi*, are sought by Sphingidæ or hawk moths. The genera Lilium and Tulipa excellently illustrate the transition from yellow to red, presenting every intermediate step, as yellow, orange, orange-red with a broad yellow band, orange-red, dark scarlet with yellow stripes, and fiery red. *Tritoma abraria* is coral red and, according to Gray, changes to orange and then to greenish-yellow.

Erythronium, Calorchortus, and Muscari are visited by bees, and display the most brilliant colors. The 4 native species of Erythronium are respectively yellow, white, rose, and lavender; and those of Muscari are blue and white, but under cultivation there are also yellow and red forms.

The genus Yucca is chiefly confined to Mexico and the southern states, but 3 species occur north of Tennessee. The flowers are large, white above and greenish beneath, and are pollinated at night by a white Teneid moth, *Pronuba yuccasella* A plant in bloom is a magnificent sight, the flower stalk sometimes, as in *Y. filifera* of Mexico, rising to the height of 50 feet and supporting a panicle 5 or 6 feet long. The manner of pollination is phenomenal in the extreme and has been thoroughly investigated by Riley and Trelease. The structure of the moth Pronuba is very abnormal among lepidopterous insects, as it is provided with tentacles for collecting

pollen and an ovipositor for puncturing the yucca pods. In the evening this small moth climbs in succession half a dozen stamens, and collects the pollinia in a compact ball beneath its head; it then punctures the pod and deposits its eggs among the ovules, after which, in order that the growing seed pods may afford food for the young larvæ, it deliberately climbs the short style, and intentionally rubs the pollen with its tentacles upon the viscid stigma. As the stamens are shorter than the pistil the plant would not produce seed unless fertilized by Pronuba.

The Convallariaceæ commonly grow in moist woods and thickets, and have dull-colored, rather inconspicuous flowers. Of the 23 species 2 are greenish-yellow, 11 white, 1 rose-purple, 4 purple, and 5 green; there are no bright red or blue flowers, and none adapted to Lepidoptera. The most frequent visitors are bees and flies. The greenish flowers of Asparagus are mellifluous, pleasantly scented, and mellitophilous. The male flowers are twice the length of the female, and in consequence of their increased conspicuousness are visited first by bees. On the greenish-yellow flowers of *Clintonia borealis* I have collected the honey-bee, *Bombus consimilis*, and small beetles, *Anthobium pothos*, feeding on the pollen. The short, white, bell-shaped flowers of Convallaria are open to all bees, but the longer tubular blossoms of Polygonatum only to bumblebees. The largest genus is Trillium with 8 species; 3 white, 4 purple, and 1 greenish. The purple-flowered species have been derived, apparently, directly from the primitive green, for *T. viride* is light green or purplish-green, *T. erectum* is purple, sometimes greenish, and *T. sessile* is purple or green. A white variety of *T. erectum* is common, especially in New York, the specimens of which in my herbarium are smaller than the purple form. C. M. Weed saw the flesh fly, *Lucilia cornicina*, on the flowers of this species, which has a disagreeable odor, and I have also seen minute Diptera. Several species are pleasantly odorous and are probably visited by small bees. The Smilaceæ have small, regular, diœcious, greenish flowers attractive to Diptera.

The Amaryllidaceæ are principally a tropical family, only

1 species, *Hypoxis hirsuta*, star grass, being found in New England. The flowers are often white, sweet-scented, and attractive to night-flying Lepidoptera. Of the 6 northern species, 3 are yellow and 3 white. The coloration of the exotic species is unsurpassed in beauty and magnificence, orange, white, red, and crimson predominating.

In the Iridaceæ, on the contrary, blue, violet, purple, and yellow are the more common colors, often variegated and gaudily spotted. The flowers of Iris are adapted to the larger bees, though the bright yellow *I. pseudacorus*, naturalized from Europe, has been seen both there and in New England to be frequently visited by a syrphid fly of the genus Rhingia. On *I. versicolor* I have taken four different bees; the honey-bee often passes in and out sideways between the perianth segment and the petaloid style without effecting fertilization, and *Halictus similis*, also common, I have observed breaking open immature anthers for the pollen. Yellow markings, yellow flowers, and reversion to yellow are of frequent occurrence, especially in Iris and the familiar Gladiolus and Crocus, and point to this color as belonging to an earlier stage of this family.

At the head of the monocotyledons stand the magnificent and extensive family of the Orchidaceæ, which, according to Engler, has no possible connecting link with the liliaceous families. The flowers are zygomorphous in a very high degree and possess marvelous adaptations for fertilization by insects, which have been very fully described, but can only be properly understood by the examination of living specimens. Of the 61 northern species, 10 are yellow, 18 white, 8 red, 14 purple, and 11 green. The number of white and green flowers appear surprisingly large until it is observed how sparingly our indigenous species are visited by insects. There are no blue flowers, and this is an unusual color among orchids, though found in the pale blue *Vanda cærulæ* of India. There is much variegation, and reversion to white of the pink-purple forms is common as in *Habenaria grandiflora* and *Pogonia ophioglossoides*. Many of the large pink-purple or rose-colored flowers are attractive to bumblebees. *Orchis spectabilis* blooms in early springtime and is visited only by female forms of Bombus, which are then

alone on the wing; during two years I have repeatedly examined many blossoms of the handsome *Pogonia ophioglossoides*, but have collected only a single specimen of *Bombus consimilis*. The white flowers of Gyrostachys (Spiranthes) and Peramium (Goodyera) are also occasionally visited by bumblebees. The genus Habenaria is adapted to Lepidoptera, the white and yellowish species, which are often sweet-scented, being pollinated by crepuscular or nocturnal moths. In some instances I have found the grayish hairs of these insects adhering to glutinous surfaces. The fertilization of some 10 species has been described by Asa Gray. Small purplish or green flowers are visited by small Hymenoptera and Diptera or are self-fertilized. On the purplish and greenish inflorescence of Listera, twayblade, Darwin collected in England small Hymenoptera and Diptera, and on the extremely small and inconspicuous but odorous flowers of *Herminium mornorchis* George Darwin collected 27 specimens of minute Hymenoptera, Diptera, and Coleoptera, the largest being less than $\frac{1}{20}$ of an inch in length. The small green flowers of *Habenaria hyperborea* and *Epipactis viridiflora* are self-fertilized. Scentless plain green flowers of a species of Epidendrum in South Brazil, according to Fritz Müller, freely secrete honey and attract insects.

A simpler and earlier stage of the Orchidaceæ has been partly preserved in Cypripedium, the floral organs of which are less modified than those of other genera. An enormous amount of extinction, Darwin believes, has swept away the intermediate forms. The flowers are visited with extreme rarity by Andrenidæ, while species of Bombus are liable to be held captive and perish miserably of starvation. Of the 6 species in the northern states, 2 are yellow, marked with purple, 2 white striped with purple, and 2 red and white. As the lip is evidently the chief object of attraction the other perianth segments are dull colored, green, brown, white, or purple.

The Orchidaceæ are remarkable for the variety of colors, often three or four, presented by individual flowers; in a species of Dendrobium from India the sepals and petals are white, tipped with purple, and the lip is bright orange with two crimson spots. This is probably due to the marked tendency of

the species to variation, as described by Müller and others, and to which they attribute the multiplicity of forms of flowers. The high degree of zygomorphy and bright coloration have evidently been produced by the agency of insects, since the lip, the petal most modified in form and color, is the segment most visited, while the other segments of the perianth often retain their primitive form and plain green coloring. Insects have not, however, been able to induce particular colors, but their work has been the fixation by selection of those naturally produced by the flowers. This is well shown by the rarity of blue among the Orchidaceæ. This color is very attractive to bees, yet its development has not necessarily followed the high specialization of the flowers in response to their visits. Its presence or absence is rather dependent upon the chemical constitution of the nutritive fluids or other internal conditions. There may even be no bright coloring, as in the mellifluous plain green species of Epidendrum mentioned above.

The monocotyledonous families were probably very early differentiated, and their subsequent development has proceeded along parallel lines, but without any connection with each other. With few exceptions, the families possess a perianth, though it is frequently rudimentary, and in the majority of species non-petaloid. In the opinion of Engler the floral envelopes have not been induced by insect pollination. Their very general occurrence points to their early development, and their first office was undoubtedly protective in its nature, similar to that performed by the scales of the gymnosperms. In anemophilous families the perianth has remained unmodified or, where the protective office has been assumed by glumes or bracts, as in the Gramineæ, has nearly disappeared; while in the entomophilous families insect pollination has caused it to be enlarged and specialized. When the expenditure of producing petals, nectar, and color is considered, as well as the vast number of individuals blooming at a time when they would be brought into competition with many entomophilous flowers, it cannot be doubted that the Gramineæ and Cyperaceæ are more efficiently pollinated by the wind than could possibly be the case by the existing number of insects.

SUMMARY.

1. The primitive color of the perianth of the monocotyledonous families was green, as it still is in the greater part of the species which are anemophilous or self-fertilized. A few of the oldest families, with an indefinite number of stamens and carpels spirally arranged, have probably never possessed floral envelopes.

2. Yellow, white, and lurid, or greenish-purple flowers have in numerous instances been derived directly from the primitive green; red flowers have passed through a yellow or white stage; and blue and purple-blue have been derived from yellow, white, or red forms. Reversion to white is most common, but reversion to red or yellow also occurs.

3. Physiological conditions appear to have often played an important part in determining the coloration of the petals, while "insects have contributed to the fixation of such characters when once acquired."

4. In general, among monocotyledons yellow flowers are visited by bees and flies; white flowers, by bees, nocturnal Lepidoptera, flies, and beetles; lurid-purple, by flesh flies; red, by bees and butterflies; and blue, chiefly by bees. Red and blue flowers usually have the honey concealed, which is a far more effective cause of the limitation of insect visits than color.

When the honey is abundant and exposed, and the flower pleasantly odorous, it may prove attractive to any anthophilous insect. In proof of this it may be stated that insects frequently attempt to visit flowers from which they are excluded. I have seen butterflies standing beneath the perianth of *Iris versicolor* and stealing the honey, without rendering any service in return; an hymenopter, probably an ichneumon fly, was observed, but not caught, examining the center of the flower for nectar, and of course, unsuccessfully; flies are attracted by the bright colors of *Impatiens biflora* to the outside of the calycine sac, and I have often seen *Philanthus solivagus* flying from flower to flower of *Chelone glabra* and examining the lips for nectar, but never entering the corolla.

THE COLORS OF NORTHERN MONOCOTYLEDONOUS FLOWERS.

ORDERS.	FAMILIES.	YELLOW.	WHITE.	RED.	PURPLE.	BLUE.	GREEN OR DULL COLOR.	TOTAL.
Pandanales	Typhaceæ						2	2
	Sparganiaceæ						4	4
Naiadales	Naiadaceæ						42	42
	Scheuchzeriaceæ		1				3	4
	Alismaceæ		19					19
	Vallisneriaceæ		3					3
Graminales	Gramineæ						371	371
	Cyperaceæ						334	334
Arales	Araceæ	1	2				5	8
	Lemnaceæ						11	11
Xyridales	Mayacaceæ		1					1
	Xyridaceæ	6						6
	Eriocaulaceæ						5	5
	Bromeliaceæ	1						1
Liliales	Commelinaceæ			1		11		12
	Pontederiaceæ	1	1			2		4
	Juncaceæ						47	47
	Melanthaceæ	7	10		2		5	24
	Liliaceæ	6	13	11	1	6	1	38
	Convallariaceæ	2	11	1	4		5	23
	Smilaceæ						11	11
	Hæmodoraceæ	1						1
	Amaryllidaceæ	3	3					6
	Dioscoreaceæ	1						1
	Iridaceæ	2		1				17
Scitaminales	Marantaceæ				1	14		1
Orchidales	Burmanniaceæ					1		1
	Orchidaceæ	10	18	8	14		11	61
	Total	41	82	22	22	34	857	1058

LOSS OF THE ECTODERM OF *HYDRA VIRIDIS* IN THE LIGHT OF A PROJECTION MICROSCOPE.

WILLIAM L. TOWER.

WHILE working with a projection microscope in December, 1897, I placed a living *Hydra viridis* in a small stage aquarium and projected its image upon a screen. The response of the hydra to this stimulus was startling.

My apparatus consisted of an alternating current arc-lamp of fifty-two volt, twelve ampere capacity. The light was taken by a pair of four-and-one-half-inch condensers, and was passed by them through an alum cell to remove the heat rays, then through a bi-convex condensing lens, an Abbé condenser, and finally through the object into the objective.

Projected in this manner, an unexpected sight was visible on the screen. The ectodermal cells, either singly or in groups, were seen to leave the animal, float free in the liquid, and gradually sink out of sight, leaving the hydra composed solely of endoderm, and the thin layer of mesodermal tissue. The cells were not distorted in any way, but retained their normal shape, acting as if they had been separated by some delicate and effective disassociation method. This result, and the fact that it could not be due to heat, as will appear later, led to the further investigation of the phenomenon.

The material had been collected in October, and kept in the laboratory, where it had multiplied to a considerable extent. The hydræ were removed one at a time with a pipette, and placed in the stage aquarium ordinarily used for such purposes, where they were left from twelve to eighteen hours, during which time they fully recovered from being handled. They were then carefully placed upon the stage of the projection microscope. By using sufficient care it was possible to bring the animal at once into the field in an unstimulated condition and fully expanded.

In each of the one hundred and twenty-four times a hydra was placed in the field of the microscope it immediately underwent violent contraction, followed by speedy recovery of the elongated form. In four cases a response of this kind was noted in five seconds from the time the hydra was placed in the light. In two cases a period of forty seconds elapsed before any response was noted.

This response was accompanied by the discharge of a number of the nettle cells on the tentacles. In the great majority of cases the loss of the ectodermal cells began about the time when the animal regained its elongated form. Usually all of the ectoderm was lost, but in a few individuals a small number of cells would adhere to the upper part of the animal. In one case the ectoderm was completely lost in one minute, while another required eleven minutes for its removal (see table, also Fig. 1).

TABLE OF RESPONSES OBTAINED.

Total number of individuals, 124.

First response:

Time in seconds,	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*
No. of individ.,	4	71	6	2	1	10	28	2

Lost ectoderm:

Time in minutes,	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*
No. of individ.,	1	0	6	10	80	7	1	2	3	13	1

Ectoderm regenerated:

Time in days,	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*
No. of individ.,	1	0	4	7	7	10	20	30	20	12	3	1	0	0

	23	*24*	*25*	*26*	*27*	*28*	*29*	*30*	*31*	*32*	*33*
	1	2	1	0	0	0	1	2	0	1	1

Time lived after second trial:

Time in days,	*3*	*4*	*5*	*6*	*7*	*8*	*9*
No. of individ.,	2	2	10	42	44	14	10

The first response is evidently due to the concentration of light upon the animal. An interesting point about the response to the light stimulus is the grouping of the individuals about two modes (Fig. 2). One set responds quickly, and tends to gather about a mode of ten (seconds). The other set requires

a continued application of the stimulus for a longer time before the response takes place. These latter tend to group themselves about a mode of thirty-five (seconds). Between these two almost no cases were found.

I cannot explain the loss of the ectoderm. It could not be due to heat, for the alum cell effectually cut out that element, as was shown by placing the bulb of a delicate thermometer in

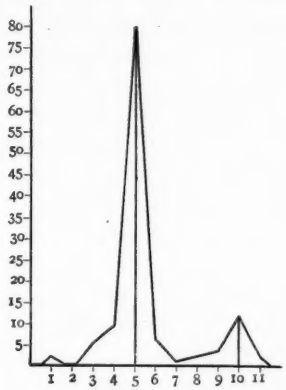

FIG. 1.

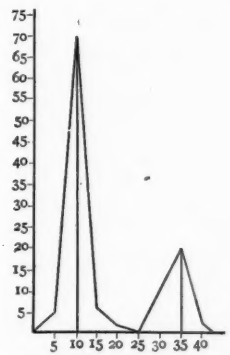

FIG. 2.

FIG. 1. — Curve of the first response. The ordinates represent time (in seconds), and abscissas represent individuals. It is to be noted that the individuals fall in two classes with one mode at ten and the other at thirty-five seconds.

FIG. 2. — Loss of ectoderm. Curve showing the arrangement of the individuals about two modes; one at five, the other at ten (minutes). Ordinates = time in minutes. Abscissas = number of individuals.

the aquarium containing the hydra. There was no change whatever, and the water remained constantly at the temperature of the room, which ranged from 15° to 18° C. It could not have been due to escaped currents of electricity, for insulation was perfect. Neither could it have been the effect of the Roentgen rays, although such are found in the arc-light. The distance of the object from the arc was forty-two inches, and the small amount of those rays generated by the arc-lamp could not have had, it seems, any effect at so great a distance, inasmuch as they were not focused or controlled by optical appliances. This dropping off of the hypodermis, however, resembles in many ways the blistering effects produced upon the skin by Roentgen rays.

No experiments were made to determine what light rays were responsible for this, excepting that it was noted in making a photo-micrograph, using light of long wave-length, that the phenomenon did not occur; but if rays of short wave-length were used, it was impossible to obtain a sharp photograph, owing to the sloughing of the hypodermis. Microscopical examination showed that the sloughing had occurred, and it was also seen on the focusing screen of the camera. Beyond this I did not determine the action of the rays of different wave-lengths, although I believe this phenomenon is in some way related to rays of short wave-length.

After the removal of the ectoderm by this means, the hydra was very unresponsive to stimuli. It remained in an elongated condition even when handled violently. Before twenty-four hours had elapsed it had contracted into an oval mass, with the tentacles almost entirely retracted; but it recovered its normal expanded condition in three or four days.

It is interesting in connection with this to note the regeneration of the ectoderm. Each hydra, after having been subjected to this treatment, was placed in a small bottle and given plenty of fresh water until it recovered. The most rapid recovery took place in nine days, while the slowest required thirty-three. The great majority recovered in from fifteen to seventeen days (see table). I have made no histological study of the regeneration of the ectoderm, but observed it with considerable constancy in the living animals, and found that it appeared first about the oral end.

If a hydra after complete recovery, that is, after complete regeneration of the ectoderm, was again subjected to the same treatment, the second response to light would occur in about the same time as before, and usually fall in the same modal class. This was true also for the loss of the ectoderm. It was noted, however, that some of the individuals that responded quickly to light and to the stimulus that removed the ectoderm in the first trial showed a near approach, or completely conformed to the second modal class in the second trial.

I was not able to obtain a second regeneration. The hydra did not recover at all, but remained as if stupefied, moving only

when chemically stimulated. In three or four days it would be found contracted, and in six or seven days would macerate and entirely disappear.

The case is interesting, and, as far as I know, no similar one has ever been recorded. It is manifestly a case of response to some form of radiant energy, either of light or short wave-length, or of some other form beyond the visible end of the spectrum. It would have been desirable to have carried out histological studies upon this material, but I was unable to do so at the time.

CAMBRIDGE, MASS., Feb. 10, 1899.

EDITORIAL COMMENT.

Keys for the Determination of American Invertebrates. — Beginning with the next issue the *American Naturalist* will publish a series of synoptical tables or keys for the determination of American invertebrates, each key covering one group. Each article will be prefaced by a brief account of the habits and occurrence of the forms under consideration, with hints for collecting, and will be accompanied by simple illustrations where such are necessary to emphasize points of systematic importance. An American bibliography and the best general references will form a part of each contribution. We have long had the valuable *Manual of Vertebrates* of our distinguished co-editor, Professor Jordan, and the *Naturalist* now strives to supplement in a measure this useful work by publishing synopses or keys for the invertebrates, hoping thus gradually to give to Americans an equivalent of the German 'Leunis,' corresponding to which there is nothing in the English language. The task we have set for ourselves is not an easy one. We cannot hope to cover all the invertebrates of North America, as many groups have been but partially studied, which is true particularly of western and Pacific forms. It will be our effort, however, to present to our readers brief synopses of the present state of our knowledge. We invite correction and criticism, and beg our readers to test our keys to their full capacity; and if they will send to us specimens that they cannot place in the keys, we will undertake to determine and return them. Such coöperation will aid us in enlarging and revising the keys for future issue, and help in perfecting the work we have undertaken — a Manual of Invertebrates. Uniformity of treatment can at first hardly be realized, owing to the many sources from which the contributions must come, but we look forward to the accumulation of material sufficient for the publication of at least one homogeneous volume. Eminent specialists have pledged their coöperation; the first of the series, to appear in the July issue, will deal with the fresh-water Bryozoa.

Outdoor Nature Study. — Any one who has witnessed the struggles of the average unprepared school-teacher with "nature study" knows how much in need she is of a friendly guide to take her out of

doors and teach her what nature really is. An attempt to meet this need is to be made during the summer by the Rhode Island College of Agriculture and Mechanic Arts, at Kingston, R. I., where a summer school of nature study will be held from July 5–19, provided forty applicants are enrolled before June 1. The program is rather ambitious for the short time allowed, as it includes physiography, botany, zoölogy, and horticulture. But as the work is to be chiefly in the field, if it is skillfully conducted, no doubt most teachers will be able to get from it considerable instruction and a great deal of inspiration for future work.

Vertebrate Ancestry. — The recent attempt by Roule (C. R., October, 1898) to seek the ancestry of the vertebrates in Actinotrocha, it seems to us, is the most ingenious and the most improbable of any view yet advanced. It demands that the mouth of Actinotrocha becomes the vertebrate neurenteric canal, while the vent forms the vertebrate mouth.

New "American Anthropologist." — It is with genuine pleasure that students of anthropology greet the new *American Anthropologist*, the first number of which appeared in March. The new journal replaces the periodical that appeared under the same name for the last ten years. The change is most welcome and promising. The old *American Anthropologist* served a good purpose. It was the official journal of the Washington Anthropological Society; it became the forum of smaller contributions to anthropology, and it stimulated and preserved many efforts of value, but its scope was too restricted. It was not a fair representative of the science of anthropology in this country, and could not keep up with its advancement. Thus it became evident that either the *American Anthropologist* had to undergo a radical change, or that a new, larger, more representative journal had to be established.

The first practical efforts for the establishing of a new journal of anthropology were due to Dr. Franz Boas, of New York, and Professor Wm. J. McGee, of Washington, who were soon seconded by other anthropologists of prominence. Dr. Boas formulated a definite proposition and brought it before Section H of the American Association for the Advancement of Science, at its winter meeting in Ithaca, in December, 1897. The proposition aimed rather at a metamorphosis of the established journal than at beginning a new periodical, the change taking place with the consent and coöperation of the Washington Anthropological Society. Section H of the Ameri-

can Association supported the proposition, and, following the report of its committee, at the annual meeting of the Association in Boston, in 1898, voted its approval of establishing the new journal. The coöperation of the Washington Anthropological Society was secured, and it was decided to discontinue the old journal and allow the new, more efficient periodical to take its place. By almost common consent of the subscribers, the new journal was to retain the name of the old one.

As to the aims of the new *American Anthropologist*, we cannot do better than quote its editors: "The editors aim to make the journal a medium of communication between students of all branches of anthropology. The contents will embrace (1) high grade papers pertaining to all parts of the domain of anthropology, the technical papers to be limited in number and length; (2) briefer contributions on anthropologic subjects, including discussion and correspondence; (3) reviews of anthropologic literature; (4) a current bibliography of anthropology; and (5) minor notes and news." The purpose of the *American Anthropologist* will be "to disseminate as widely as practicable, for the use of scholars and of students, the results of anthropologic investigations."

The Editorial Board of the new journal is composed of Messrs. Frank Baker, W. H. Holmes, and J. W. Powell, Washington; Franz Boas, New York; Daniel G. Brinton, Philadelphia; F. W. Putnam and Miss Alice C. Fletcher, Cambridge; Geo. A. Dorsey, Chicago; and Geo. M. Dawson, Ottawa, with F. W. Hodge, of Washington, as the managing editor and secretary.

It is evident that the establishing of this new, more efficient journal marks a real progress in American anthropology.

REVIEWS OF RECENT LITERATURE.

ANTHROPOLOGY.

Explorations in the Far North. — The volume at hand is a report, by Dr. Russell,[1] of an expedition, under the auspices of the University of Iowa, during the years 1892–94, to the region of the great Canadian lakes. The principal aim of the expedition was to obtain specimens of the larger northern mammals; the author supplemented this with additional investigations in natural history and ethnology of the regions visited.

The work was apparently intended not to be too technical. It is written in a popular vein and contains many interesting incidents of hunt and travel. At the same time the report is interspersed with valuable ethnological and zoölogical data. The ethnological material comprises numerous notes on the natives of Saskatchewan, on the Athabascans, Crees, and Eskimos. The text is accompanied by a map and numerous illustrations.

The book is printed on good paper and makes throughout interesting and instructive reading. HRDLICKA.

West African Studies. — Miss Kingsley's *Studies*[2] includes the narrative of her journey to the west coast, the climate of that region and its effect upon foreigners, the religion of the natives, commerce, and the crown colony system. The book is written in a vivacious and entertaining style, though at times affected and verbose. Its greatest value to the ethnologist lies in its account of the character of the natives, and especially of their religious beliefs. It is to be regretted that Miss Kingsley did not follow the wholesome advice given by Tylor and call religion by its right name. The opinion is advanced that neither Christianity nor Mohammedanism in their pure forms will become the prevailing religion of the West Africans, though they now believe in a Supreme God, and the idea of a man-God, or mediator, appeals to them. Miss Kingsley divides West

[1] Russell, Frank. *Explorations in the Far North*. Davenport. Published by the University of Iowa, 1898. 290 pp., plates and map.

[2] Kingsley, Mary H. *West African Studies*. Macmillan, 1899. xxiv + 639 pp. Illustrations and maps.

African religion into four "schools," *viz.*, the Tshi and Ewe, Calabar, Mpongwe, and the Nkissim or Fjort. The first of these is mainly concerned with the preservation of life, the Mpongwe with the attainment of material prosperity, and the Nkissi with the worship of the mystery of the power of earth — Nkissi-nsi. The geographical distribution of these leading forms is not known. "Sierra Leone and its adjacent districts have not been studied by an ethnologist. We have only scattered information regarding the religion there." The dominant idea in the "Calabar School" is reincarnation, with attendant human sacrifice at the time of burial. The Mpongwe are a negro race with a Bantu language, and the religion "they have elaborated and coördinated is Bantu in thought form." "It has no gods with proper priests. Human beings are here just doing their best to hold their own with the spirit world, getting spirits under their control as far as possible, and dealing with the rest of them diplomatically." Fetishes are everywhere common; in addition to the fetish of the town preserved in a fetish house, "every fetish man or priest has his private fetishes in his own house, one of a bird, stones encased by string, large lumps of cinder from an iron furnace, calabashes, and bundles of sticks tied together with a string. All these are stained with red ochre and rubbed over with eggs." The material objects are not worshiped in themselves but as the things in which the spiritual agencies take up their residence. While this account of the religion of the West Africans is suggestive and entertaining it is by no means monographic.

The interesting chapter upon the "Witch Doctor" is addressed rather to the general reader than to the ethnologist; the conclusion is that the witch doctors who succeed in having people killed for bewitching do more good than harm. "As to their using hypnotism, I suppose they do use something of the sort at times."

Miss Kingsley ascribes the failure of the English in the more unhealthy portions of the tropics to the crown colony system. In West Africa this has resulted in the disorganization of the native society with no compensatory building up. Wars are no longer carried on by the English for the purpose of stamping out slavery, human sacrifice, and the like, but for the sake of conquest. In the dark race have been implanted the strongest feelings of fear and distrust, while the whites in arrogance and ignorance strive to impose their culture upon the subject race without regard for native customs or native needs. Property is of three classes: ancestral, connected with the office of headmanship; family, in which every member has

a certain share; and private, that which is gained by private exertion in addition to that which properly belongs to the first two classes. The general tendency, however, is for all property to become family property. Mother-right prevails, and all forms of property are subject to the same law. "In West Africa there is not one acre of land that does not belong to some one."

In an appendix of 123 pages M. le Compte C. N. de Cardi describes the customs, religion, etc., of the Niger Coast Protectorate. The custom of sacrificing human beings, we are told, has been steadily increasing of late years at Benin City, which has become more and more a holy city among the pagan tribes. He repeats Miss Kingsley's statement that the natives believe in a Supreme Being, but as he is always doing good, the sacrifices are not intended for him, but for a malignant spirit whose thirst for blood is thus appeased. Among the "Brassmen" the feather ordeal is employed for the detection of criminals. The Ju-Ju man thrusts a feather from the under part of a fowl's wing through the tongue of the accused, forcing the quill down from above; if the feather breaks as he draws it out below, the person is guilty. In New Calabar the Ju-Ju priest can "so disguise a person that his own mother would not recognize him," as one of the natives declared, and "that they could cause a tree on the banks of a river to bend its stem and imbibe water through its topmost branches; that they could change themselves into birds and fly away; and, lastly, that they could make themselves invisible before your eyes, and so suddenly that you could not tell when they had done so." Throughout this book we are impressed with the fact that human life is very cheap in West Africa; witchcraft, human sacrifice, cannibalism, murder, and slavery, which alone have taken 4,480,000 souls from this coast during the last two centuries, all contribute toward making West Africa an unpleasant place to live in, even if the climate itself were not a murderous one for both whites and blacks. In the Niger Delta infanticide is quite common; twins and children born with teeth are destroyed, as well as women who become the mothers of more than four children. The work contains many illustrations of interest to the ethnologist. FRANK RUSSELL.

Mythology of the Bella Coola Indians.[1] — The Bella Coola tribe has diminished in numbers, owing to the ravages of disease, until it now contains but a few hundred souls. They speak a dialect of the Salishan language, but are isolated from the main body of

[1] Boas, Franz. *Mem. Am. Mus. Nat. Hist.*, vol. ii, Pt. ii. New York.

the Salish. Their habitat is restricted to two narrow fiords on the central portion of the coast of British Columbia. Through long-continued contact with tribes of other stocks around them they differ from the Southern Salish in both physical appearance and in customs and beliefs.

Dr. Boas refers briefly to the papers hitherto published relating to the Bella Coola, and then presents a general description of the mythology of the tribe. "All the collections which have been made heretofore do not bring out clearly the principal characteristic of the mythology of the Bella Coola. The tribes of the North Pacific coast consider the sun as the most important deity, but at the same time they believe in a great many beings of supernatural power. For this reason their mythology is very unsystematic. The Bella Coola, on the other hand, have developed a peculiar mythology, in which a number of supernatural beings have been coördinated." They believe that there are five worlds, of which this earth is the middle one; above are two heavens, and beneath are two underworlds. The supreme deity is a woman, who lives in the upper heaven and interferes but little with the affairs of men. In the center of the lower heaven stands a house, in which reside the Sun and all the other deities. Our earth is an island floating in the ocean.

"The underworld is inhabited by the ghosts, who are at liberty to return to heaven, whence they may be sent down again to our earth. The ghosts who die a second death sink to the lowest world, from which there is no return." Following the description of the deities and their abodes is an account of the village communities and their traditions; miscellaneous traditions; and, in conclusion, a sketch is offered of the probable lines of development of the mythology of the Bella Coola. The tribe is endogamous and divided into village communities. Six plates accompany the text, depicting the masks used to represent the mythical personages. This memoir must prove to be of value to the general student of ethnology as well as to the specialist.

FRANK RUSSELL.

Anthropological Notes. — Édouard de Sainville has published a brief account of his journey to the mouth of the Mackenzie River, and of his explorations about the Delta, in the *Bulletin of the Société de Géographie de Paris*, T. xix, pp. 290–307. The article is accompanied by a map which locates the harbor discovered by the Count, and which corrects errors in the coast line as now represented on our charts. As de Sainville became intimately acquainted with the natives

during his four years' residence among them, it is to be hoped that he will furnish a more complete account of them than appears in the few pages of this paper. Reports from the missionaries stationed at the trading posts maintained near the head of the Mackenzie Delta, show that the germs of disease are frequently brought into the region in the bales of merchandise, particularly in those of second-hand clothing intended for the Indians. Count de Sainville observed that an epidemic influenza prevailed for two or three weeks after the annual arrival of the steamer with the "outfit" for the post. In order to be certain that this epidemic was due to imported germs and not to sudden changes of temperature that prevail during the month of July when the steamer arrives, he took a sealed zinc case in the month of September, 1891, to a camp about fifteen miles south of the post. A father, mother, and four children were in the camp in perfect health; to these the clothing contained in the case was given. The next morning the mother and two of the children were sneezing, and that evening the symptoms of the mother were more serious. The prompt use of camphor restored them to health within a couple of days.

In the *American Anthropologist* for January, 1899, Miss Alice C. Fletcher gives an account of the ritual used when changing a man's name among the Pawnees. "Why an Indian changes his name after any important achievement, and why he never uses the personal name when addressing another, has not yet been fully explained; therefore, any first-hand information relating to this subject will undoubtedly be welcome to students of anthropology." The ritual was obtained from an aged Pawnee priest whose confidence had been gained by Miss Fletcher and her assistants. Three facts were learned: *First*, a man was permitted to take a name only after the performance of an act indicative of great ability or strength of character, such as prowess, generosity, prudence, courage, or the like; *second*, the name had to be assumed openly, before the people to whom the act it commemorated was known; *third*, it was necessary that it should be announced by a priest in connection with such a ritual as that described. The ritual is given in sixteen lines of the original Pawnee, followed by a literal translation and a free rendering in rhythmic form.

F. R.

GENERAL BIOLOGY.

Effect of Chemical and Physical Agents upon Growth. — The second part of Dr. Davenport's useful *Experimental Morphology*[1] will be welcomed by all students of the theoretical aspects of biology. This volume deals with the effects of external conditions upon growth. The first chapter is devoted to the consideration of the phenomena of normal growth, which is defined as increase in volume. Three factors are recognized — increase of formed substance, of plasma (protoplasm), and of enchylemma. Special emphasis is laid on the importance of the imbibition of water at the period of most rapid growth. Characteristic curves are given showing at first a rapid increase in the rate of growth, which soon reaches a maximum, and then more gradually declines to zero. The final cessation of growth is to be explained by special reasons for each species, and is not due to any general law.

The following chapters treat of the effects upon growth of chemical agents, water, density of the medium, molar agents, gravity, electricity, light, and heat. In each of these the effect of the agent considered is treated first in regard to its effect upon the rate of growth, and then as to its effect upon the direction of growth. The molar agents affecting growth include contact, rough movements, deformation, wounding, and the flow of water. A final chapter is devoted to the effects of certain complex agents upon growth and to general conclusions.

The book has comparatively little to do with theory. It is essentially a very careful and complete résumé of the records of laboratory experiments in the field which it covers. The only experiments that have not been published before are those described on page 365. They were made by Messrs. Frazeur and Sargent in the zoölogical laboratory at Harvard, and their object was to determine the effect of concentration of medium upon the rate of regeneration and fission in certain annelids — a species of Nais and *Dero vaga*. This lack of newness does not lessen the value of the work, however. A glance at the extensive bibliography at the close of each chapter is enough to convince one of the service that the author has performed for biology by bringing together this immense amount of material in so compact and accessible a form.

[1] Davenport, C. B. *Experimental Morphology*, Pt. ii. Effect of Chemical and Physical Agents upon Growth. New York, Macmillan, 1899. pp. 281–509. Illustrated, 8vo.

Persons unfamiliar with the present trend of biological research will be surprised at the large amount of quantitative work exhibited in this record of experiments. Wherever possible, the author has pointed out the adaptive character of the reactions observed in the laboratory. Some readers may be disappointed to find that he has not gone farther than this, and discussed the effects of chemical and physical agents upon the forms of animals and plants in the state of nature. The reason that he has not done this is, doubtless, in the first place, the fact that in nature the effects of these agents upon growth is complicated with their effects upon differentiation, which will be treated of in a later volume; and, in the second place, the lack of material. When the effects of agents under control in the simplified conditions of the laboratory are understood, we may hope to solve the problem of form as presented under the complex conditions of the natural habitat. The work under review is an important step in that direction.

In most cases where the direction of growth is changed in response to stimulation, true tropism, the result is to place the organ in a more favorable position. It is clearly adaptive. The reactions classed under the head of electrotropism, on the other hand, cannot be shown to be adaptive, because organisms never meet with the stimulus employed in the state of nature. Yet the reaction takes place with as much precision as the response to light or heat.

The most interesting of the general conclusions is in regard to the phenomena of "attunement." In several kinds of tropism, as the strength of stimulation is increased, a critical point is reached where the effect changes from positive to negative. This critical point differs in different species, and may be regarded as indicating an optimum intensity to which the organism is attuned. How is this attunement established? Natural selection is rejected and "a cause more consistent with sound physiology" is sought.

It has been shown that the effects of various agents persist after the stimulus has been removed. This "after-effect" seems to show that the agent causes a change in the protoplasm which is more or less permanent. This permits the accumulation of extremely slight effects. When, however, the repeated stimuli are each great, it is not an accumulation, but a diminution of response that is noticed. The organism becomes gradually accustomed to the stimulus and ceases to respond. It is acclimated. The author's hypothesis to explain this is that the chemical change which leads to the response becomes a permanent characteristic of the protoplasm so that no

further response to that particular strength of stimulus is possible. This individual attunement may persist, and may be inherited and thus initiate a racial attunement.

The author does not claim that this is a complete explanation of the facts. It is merely a tentative hypothesis. But it is almost too soon to attempt even an hypothesis, for if we try to compare the critical points of the various kinds of stimuli in their effects upon the rate and the direction of growth, in order to see what relation exists between them and how they are related to adaptive responses of the organism, we find the data often contradictory and always inadequate. For example, if we compare the tables given on page 439, we find that of the seven species mentioned in Table 45, only four are to be found in Table 46. Moreover, the first mentions the organs affected, while the second leaves us in doubt as to whether we are dealing with root or stem. Similar difficulties arise in an attempt to compare the table on page 454 with those on pages 464 and 465. All this goes to show that, in spite of all that has been done, more work is needed, and the author's hypothesis will be of value if it serves no other purpose than to stimulate research from a broad point of view.

We notice few errors and omissions. On page 411, line 4, for *plant* read cylinder. The important work of Martin and Friedenwald[1] on the effect of light upon metabolism in animals has been overlooked. On page 440 a diagram of the spectrum is given, showing an interesting coincidence between the point of maximum retardation of growth and that of no phototropic effect. But this coincidence is not mentioned in the text.

R. P. B.

Variation Statistics.[2] — In this work Duncker provides naturalists with the new tool which the English anthropologists, zoölogists, and mathematicians have developed. Many of the works of the mathematicians, especially the invaluable treatises of Pearson, have been beyond the mathematical training of most biologists. In this paper the results of these treatises are given in a comparatively simple fashion. Great stress — relatively too much in the reviewer's opinion — is laid on the methods of constructing the various types of

[1] Martin, H. N., and Friedenwald, J. Some Observations on the Effect of Light on the Production of Carbondioxide Gas by Frogs, *J. H. U. Studies*, iv, 5, p. 221, 1889.

[2] Duncker, G. Die Methode der Variations-Statistik, *Ant. für Entwickelungsmechanik der Organismen*, Bd. viii, pp. 112–183. Feb. 21, 1899.

curves agreeing with any observed distribution of varying individuals. To solve some of the equations, logarithms, trigonometric functions and gamma functions have to be employed, and it is too much to hope that a large proportion of naturalists can use even these simple methods. Yet naturalists who desire to reach best results from their data must get out their algebras, trigonometries, and logarithmic tables, and brush up on these subjects. Formulas are used very freely, which is no doubt an offense to some. It should be remembered, however, that a formula is only an abbreviated statement of operations, and very useful to any one who knows how the operations indicated are performed. The author gives the various indices of variability. He objects to the use of the coefficient of variability (obtained by dividing the index of variability by the mean) and maintains that the view that we expect high indices of variability where the mean is high is untenable. As evidence for this conclusion he points to the fact that in the four numerical examples given in his paper the index of variability is inversely proportional to the mean. This is, however, absolutely no evidence against the value of the coefficient of variation, since, doubtless, the large characteristic which has a small index of variability is, in comparison with the small character having a large index, relatively even less variable than a comparison of the mere indices would indicate.

Correlation is treated of briefly, and an excellent short method of calculating the coefficient of correlation is given. The calculation of spurious correlation of indices is not given — an important omission ; and little is said about multimodal curves, which are frequent in biological statistics.

A bibliography of 111 titles is given (from which Fechner's 1897 work is omitted), and tables of formulas add greatly to the usefulness of the paper.

Altogether the paper is one which every student of statistical biology — *and this ought to include every systematic worker in zoölogy and botany* — should have.

Inheritance of Acquired Qualities.[1] — Conidia of *Aspergillus niger* of common origin are reared (*A*) in Raulin solution; (*B*) in Raulin solution + 6 per cent NaCl for *one* generation; and (*C*) in Raulin solution + 6 per cent NaCl for *two* generations. Then :

[1] Errera, L. Hérédité d'un caractère acquis chez un champignon pluricellulaire, *Bull. Acad. Roy. de Belg.*, 1899, pp. 81–102.

I. In a Raulin solution + 18.4 per cent NaCl:
A, shows no germination;
B, slight germination;
C, general germination.

II. In a Raulin solution + 6 per cent NaCl:
A, produces spores in 5 days;
B, produces spores in 4 days;
C, produces spores in 3¾ days.

III. In a Raulin solution, without additional salts:
A, sporification in 4 days;
B, sporification in 5 days;
C, sporification in 5 days, but slight.

Spores from cultures III, *A*, *B*, and *C*, are sowed in Raulin solution + 18.4 per cent NaCl:

IV. *A'*, after 5 days, no germination;
B', after 5 days, just visible germination;
C', after 5 days, clearly visible germination.

Hence (I and II) the Conidia of Aspergillus become adapted to the medium in which their parent is growing, and more adapted after the second generation than after the first.

The adaptation is such that a normal solution is disadvantageous to Conidia adapted to a dense solution.

The adaptation to concentrated medium is not wholly lost after rearing in a normal medium. (IV.) There is a persistence of the adaptation, there is an inheritance of the acquired quality of resistance to concentration.

ZOÖLOGY.

Evans's Birds. — The ninth volume of *The Cambridge Natural History*, comprising the *Birds*, by A. H. Evans,[1] has just come to hand.

Ornithologists have of late years been favored with several general works on the natural history of birds, by competent authors, the main object of which has been to present the results of recent studies of the structure of the various groups composing this class. On the other hand, the usual number of "popular," often inaccurate and

[1] Evans, A. H. *Birds*. The Cambridge Natural History, vol. ix. London, New York, Macmillan, 1899. xvi + 635 pp., 8vo, 144 figs. + 2 polar charts.

gossipy, accounts of the habits of the feathered tribes, without regard to the present status of the *science* of ornithology, appear regularly and find a ready sale. Realizing this, Mr. Evans has set himself a different task in the book before us. In the recent literature he has found no concise general account of the *species* of the birds presented in a popular form, and he consequently planned to give one in the 587 pages of this work. This plan precludes of course any original work, but it is in itself original enough, and daring to a degree. Manifestly a mere enumeration of the species would not do, while even the briefest description of each would more than fill the book. He has consequently been obliged to limit himself "to a short description of the majority of the forms in many of the families, and of the most typical and important of the innumerable species in the large Passerine order." But even with this limitation the task would appear well-nigh impossible. Yet, in going over the book carefully, we have to admit that he has succeeded, and succeeded admirably; for not only has he accomplished the above, but he has given in addition a compressed introduction to avian structure, external and internal; the various groups and divisions are characterized; the habits of the birds are briefly sketched in general terms, mostly under the heads of the families; and the geographical distribution of the species mentioned is often given in considerable detail. Moreover, the fossil birds are treated similarly with the recent forms, and finally 144 woodcuts in the text illustrate the principal types.

Fortunately for Mr. Evans he has been able to accept a thoroughly modern and scientific classification proposed by competent authority. It is but natural that he, as a Cambridge man, should adopt in the main Dr. Gadow's system, and we may add that he might have gone farther and not fared as well. On the other hand, so far as the species and to a great extent also the genera are concerned, he has had the benefit of the now completed series of magnificent volumes constituting the catalogue of birds in the British Museum. Finally he appears to fall back upon the "Strickland Code of Ornithological Nomenclature," the elasticity of which enables those who profess to adhere to it to follow their own ideas, or "common sense," as they are invariably styled. It is thus impossible to quarrel with Mr. Evans where one does not agree with his authorities. He has quoted them, and we have to settle our disputes directly with them.

In judging the size of Mr. Evans's task it must not be forgotten, however, that it is now twenty-five years since the first volume of the bird catalogues of the British Museum was issued, and that he has had

to bring the subject down to date, as exemplified by the "addendum" (p. viii), containing references to forms described during the printing of the *Birds*.

It will be understood that not the least difficult part of the problem has been to introduce the enormous number of species and to present the "dry matter" of their structure, color, and distribution in such a way as not to become monotonous, and to condense the account of the habits sufficiently while yet retaining a readable form. In both respects Mr. Evans has proved himself a master. Where one hardly expects to find room for the mere mention of the names, one is surprised and delighted to find pages brimful of boiled down facts, yet holding one's attention and reading as smoothly as a novel. Mr. Evans has selected for his motto Virgil's *In sicco ludunt fulicæ*, with the equivalent rendition: "Loons disport themselves on dry matters"; but he certainly does not need this humorous apology.

It is plain, however, from what has been said of the plan, that the main value of the book depends on the accuracy of the statements it contains. To verify them all is not the reviewer's task, but in the short time he has had the use of the book he has tested it in many places and many ways, and in every case found it essentially correct. Of course nothing else was expected of Mr. Evans, with his intimate knowledge of the literature and his careful and painstaking method; yet it is pleasing to find that these qualities are paired with a critical skill of no mean order. Moreover, in cases of unusual or uncorroborated statement, Mr. Evans has mostly given his authorities in footnotes. As a matter of fact most of the matter is necessarily second-hand, the responsibility of the author being chiefly confined to the selection, and of course he does not guarantee the accuracy of his informants except in a general way. Thus, on page 313, in speaking of *Sterna longipennis* having "blackish feet," he adds in a footnote that "Mr. Barrett-Hamilton, however, tells the author that the feet are red in life," while as a matter of fact the feet of this species are neither black nor red, but "blackish red" or "dark reddish brown" (Stejn., *Orn. Expl. Kamtsch.*, p. 85).

Most of the illustrations are by Mr. G. C. Lodge, apparently made specially for this book. The majority must be pronounced both accurate and characteristic, while some are admirable in every respect. The sober attitudes of the bird and the total absence of "scenery" are highly commendable. The much admired woodcuts from the *Natural History of Selborne* may be more artistic, but a comparison with those which have been borrowed from the latter work,

for instance, the wryneck and the nuthatch, shows how vastly superior the modern figures are as zoölogical illustrations. In the limited space of this volume much room could not be spared for pictures, but figures are given of representatives of most of the important groups. It may be disputed, however, whether the selection of species illustrated is the best one which could have been made for a book of this scope. Over one-third of the species figured are English, some of them the most common and best known birds with which every reader of the book is thoroughly familiar. It can hardly be doubted that a figure of Podoces would have been more valuable than that of the raven, or that Pyrrhuloxia would have been preferable to the house sparrow. However, the author is probably not to blame in the matter. Editors and publishers usually have a way of interfering with his best intentions — concerning the illustrations.

The author expresses the hope that the work may be of real use, not only to the tyro in ornithology, but also to the traveler or resident in foreign parts interested in the subject, who, without time or opportunity for referring to the works of specialists, may yet need the aid of a concise account of the species likely to cross his path. There certainly was a need of such a book, and the present one meets it as well as it can be done in the limited space. From the treatment of the various groups I may add that the class of people most likely to derive the greatest benefit from the book is the traveling sportsman with an eye open for other birds and game in the strictest sense. But even the working naturalist, let alone the tyro, will find it an inexhaustible mine of solid ornithological facts.

LEONHARD STEJNEGER.

Blind-Fishes of the Caves. — In *Science* for February 24, Dr. Carl H. Eigenmann describes a new genus of blind-fishes, which he finds a remarkable case of the convergence of characters. The species, first obtained by Mr. Garman from the caves of Missouri, was identified by him with *Typhlichthys subterraneus*, a blind species inhabiting the caves of the Ohio Valley. The two forms are almost identical superficially, but Dr. Eigenmann finds in fresh material abundant evidence that they are descended from distinct forms. The genus Chologaster, of the swamps of the South, is regarded as evidently the ancestor of Typhlichthys, but the new form from Missouri, called by Eigenmann *Troglichthys rosæ*, must have had a different ancestry in the same family. "Judging from the degree of degeneration of the eye, Troglichthys has lived in caves and done

without the use of its eyes longer than any other known vertebrate." "More than this, *T. rosæ* is probably the oldest resident in the region it inhabits."

The remaining genus of blind-fish, Amblyopsis, has ventral fins, and must therefore have had a distinct ancestry, as in the three other genera ventral fins are absent. All this points to an earlier time when the Amblyopsidæ were represented in the lowlands of the South by at least three distinct-eyed genera, but one of which, Chologaster, is now extant. Eigenmann regards Troglichthys as "in many ways the most interesting member of the North American fauna."

D. S. J.

Trout of the Olympic Mountains. — Some three years ago Rear-Admiral L. A. Beardslee brought from Crescent Lake, in the Olympic Mountains, two new forms or species, or subspecies, of trout, called by Dr. Jordan *Salmo crescentis* and *Salmo beardsleei.*

These forms are products of isolation and land-locking, the probable ancestor of both being the Steelhead trout, *Salmo gairdneri.* Lately Dr. Daniel G. Elliot, of the Field Columbian Museum, has made an extensive survey of these and other lakes in the same mountains. Other land-locked forms, also differentiated by isolation, are found, and these have been described in detail by Dr. Seth E. Meek in the publications of the Field Columbian Museum.

Dr. Meek recognizes *Salmo bathoiceter*, the long-headed trout from Lake Crescent; *Salmo clarki jordani*, the spotted trout of Lake Southerland; and *Salmo clarki declivifrons*, the salmon trout of Lake Southerland.

The question of the ultimate rank as species, subspecies, etc., of our western trout is one of the most difficult in taxonomy. Fortunately, the question is one of nomenclature only, for the real origin and relation of the various forms admit in no case of serious question.

In the same paper Dr. Meek describes new garter snakes from the same region as *Thamnophis leptocephalus olympia* and *Thamnophis rubrostriatus.*

D. S. J.

Fishes of the Revillagigedos. — In the *Report of the U. S. Fish Commission* for 1898, Dr. Jordan and Mr. R. C. McGregor give a list of the fishes taken by Mr. McGregor on the cruise of the *Wahlberg* about the Revillagigedos, off the west coast of Mexico.

The interesting feature of the collection is the large number of

typically East Indian forms obtained. The list contains sixteen species not found along the mainland of Mexico, but which are nearly or quite identical with East Indian forms. This shows the comparative continuity of the Polynesian fish fauna. Six new species are obtained, *Myrichthys pantostigmuis*, *Zalocys stilbe*, *Apogon atricandus*, *Forcipiger flavissimus*, *Cantherines carolæ*, and *Azurina hirando*. All except the Apogon are figured; Zalocys, Forcipiger, and Azurina are new genera. Most of the species recorded were obtained by the use of dynamite among the rocks.

We regret to learn from the daily press that, in a second expedition in the same region, Mr. McGregor, in his schooner, the *Stella Erland*, has been wrecked on the coast of Lower California, all his valuable material being lost. D. S. J.

The Miller's Thumb of Europe. — In the *Proceedings of the Swedish Academy*, Mr. Lars Gabriel Andersson takes up the vexed question of the relation of species in the genus Cottus, or Miller's Thumb, as shown in the waters of Europe.

This genus, in common with most others of relatively recent origin, exhibits surprising variations as represented in different waters; while, on the other hand, the characters which separate species are slight and sometimes unstable.

After a very detailed comparison Mr. Andersson concludes that *Cottus pœcilopus*, of the Carpathian Mountains, is a species distinct from the common *Cottus gobio*. Our own experience with the American species of the same genus tends to confirm his conclusions.

D. S. J.

Fishes of Santa Catalina Island. — Dr. Charles H. Gilbert reports, in the *Report of the U. S. Fish Commission* for 1898, on the Fishes obtained by the steamer *Albatross* in the vicinity of Santa Catalina Island and Monterey Bay. A large number of deep-sea forms were taken, two of them, *Radulinus boleoides* and *Averruncus sterletus*, being new to science. These species are figured in the report. D. S. J.

Helminthological Studies of Kowalewski. — A recent number of the helminthological studies of M. Kowalewski[1] presents some

[1] Études helminthologiques. V. Contribution à l'étude de quelques Trématodes, *Bull. Acad. Sci.* Cracovie, Fév. 1898. French résumé accompanying the Czeckish original, with 2 plates.

important observations. *Echinostoma spathulatum*, discovered in the intestine of *Botaurus minutus* by Bremser, and never reported since the original description of Rudolphi, was found in the same host. Its peculiar features as described by the author render it worthy of generic rank. The most striking point is the pair of retractile papillæ, armed with spines, which are found on the mid-ventral line in the posterior third of the body and serve as organs of fixation. A branch from each lateral excretory canal penetrates into each papilla and terminates there in a sac, producing a mechanism which recalls the Echinoderm ambulacrum. Cutaneous glands give rise to appearances like the tactile papillæ of Blochmann and Bettendorf; these are elevations with apparent openings in the apex and a minute duct, the connection of which with the glands was not demonstrated. Noteworthy is further the occurrence of cilia on the epithelium of the intestine.

The author then discusses three new forms of the genus Opisthorchis, in one of which the excretory pore has an unusual location, on the mid-ventral line just behind the ovary. The tendency in this genus to dextrosinistral inversion of organs, or, as Kowalewski calls it, to sexual amphitypy, which makes some individuals the mirror image of the usual type in the species, is treated at length and from evidence submitted shown to be present in half of the known species. The diagnosis of the genus is amended and its subdivisions outlined.

For the interesting *Bilharzia polonica*, discovered by Kowalewski in 1895, a large number of hosts is now reported, species of Anas and related genera. Usually the parasite is found in the blood, but occasionally in the gall bladder; its nourishment, as the author maintains, consists primarily of blood plasma and less frequently of erythrocytes. In addition to structural details previously reported, mention is here made of special dermal organs of the male, which in appearance are not unlike tactile papillæ or the cutaneous glands referred to above. These exist separately or in groups on the ventral surface, including the suckers, on the dorsum of the neck, and on the posterior margins of the body. Strings of granules from the apex connect with granular masses in the gynecophoric canal, suggesting the discharged secretion of glands; yet these masses may be of external origin. The Czeckish original is illustrated by two fine plates. However much one may admire the loyalty of the author, it is yet a matter of regret that one's knowledge of the work must be gained from a brief French résumé, because the riches of the original article are buried in such an inaccessible language. H. B. W.

Blood Spots in Hens' Eggs. — Every one is familiar with the fact that flecks of blood are occasionally seen on the surface of the yellow of a perfectly fresh hen's egg. It is evident that these flecks are derived from some maternal structure and are not a product of the development of the egg, as they are present before incubation begins and are outside the embryonic area. Professor Mitrophanow,[1] upon investigating the nature of these flecks, has arrived at some interesting conclusions regarding the origin of the egg-membranes of birds.

According to the classical description of Foster and Balfour, the yellow of the egg is enclosed by a single "vitelline" membrane, the exact source of which, however, whether from the egg itself or from follicular cells surrounding it in the ovary, is unknown.

Most recent investigators assign to it a follicular origin. Mitrophanow finds that it is really a double membrane whose parts are of different origin. Its double nature is demonstrated by the occurrence of the blood clots previously referred to not, as one might expect, on the outside of the vitelline membrane, or on its inner surface, but between the two laminæ of which it is composed.

Mitrophanow states reasons for believing that the blood clot can only have been deposited on the egg after it had left the follicle. If so, the outer lamina must have been formed in the upper part of the oviduct and accordingly must represent, not an ovarian product, but an accessory envelope. The delicate inner lamina Mitrophanow regards as a true vitelline membrane formed by the egg-cell itself.

Origin of the Fauna of the Central African Lakes. — J. E. S. Moore has published[2] very interesting researches on the fresh-water fauna of the African lakes, chiefly Lake Tanganyika. He divides the fauna into two constituents: (1) types which are represented generally in the African fresh-water bodies; (2) types which are found nowhere else in fresh water, but have relations in the ocean (halolimnic organisms).

To the latter class belong the Medusæ, discovered by Boehm in 1883, numerous mollusks, both of the shore and of deeper water, and further two species of shrimps and a deep-water crab.[3]

The mollusks are allied, in many cases, not to a single marine form,

[1] *Bibliographie Anatomique*, Tome vi, Fasc. 2, pp. 69–84.

[2] *Nature*, vol. 58, 1898, p. 404.

[3] These Crustaceans may prove to belong to the first class (generally distributed fresh-water animals), since such forms, belonging to the shrimp genus Caridina and the crab family Potamonidæ, are found all over the African continent. — *Rev.*

but to several; and it seems as if they represent connecting links between these forms like ancestral types. There seem to exist, in the Tanganyika, numerous unknown species, chiefly in greater depths, but the author had no facilities to make a collection of the fauna of these depths.

The halolimnic fauna of the Tanganyika, as a whole, has a striking Jurassic character. This fauna is positively wanting in the Lakes Nyassa, Meru, and Bangweolo, and — according to Gregory's collections — in the Lakes Naiwasha, Elineteita, Baringo, and — according to Donaldson Smith's and Cavendish's collections — in Lake Rudolf. Moore is of the opinion that the former connection of the Tanganyika with the sea was in a northerly direction, through the Central African depression that is marked by the Lakes Albert and Albert-Edward to the Red Sea. Accordingly, we are to look for the same ancient fauna in these latter lakes, although their fauna is at present unknown.

It may be that this body of sea water in Central Africa continued to exist into Tertiary times, since we have some evidence — as the author points out — of the presence of marine Tertiary deposits west of the Victoria lake, which seem to extend southward to the neighborhood of the Lake Nyassa. A. E. O.

Swiss Rotifers.[1] — The appearance of the second part completes Dr. Weber's superbly illustrated monograph of the Rotifera of the Léman. This paper is by far the most complete account of this group which has appeared since the publication of Hudson and Gosse's *Manual*. In all, 127 species are described and figured with care. With commendable moderation Dr. Weber has refrained from describing any new species, but has devoted his attention to elaborate descriptions of the forms he has found and to an elucidation of their synonymy. The result is a courageous reduction in the number of species, as is attested by the fact that no less than 292 names appear as synonyms in the index which concludes the final paper. The genus Brachionus has been a fruitful field for the species maker, and it is here that our author has done most execution. This genus includes many extremely variable forms, and the question of specific limits here is a most difficult one to solve. It may be that the statistical study of the group will throw some light upon the problem. The desirability of some designation for the many variants is

[1] Weber, E. F. Faune rotatorienne du bassin du Léman, 2me partie. Ploima et Scirtopoda. *Rev. Suisse de Zoöl*, T. v, pp. 355–785, Pls. 16–25, 1898.

evident. Abundant biological data are included in the paper. Dr. Weber proposes a new solution for the Plœsoma enigma, restoring Ehrenberg's *P. lynceum* and recognizing Herrick's *P. lenticulare.*

C. A. K.

Trematode Anatomy.[1] — Kowalewski has given an extended account of the anatomy of certain avian trematodes. He describes a number of papillæ upon the ventral surface of *Echinostomum spathulatum* Rud., each traversed by a canal with granular contents. These structures are interpreted as the outlets of glands found in the adjacent parenchyma, though a direct connection of the two was not established. Similar organs were also observed on the ventral surface, on the suckers, on the dorsal side of the neck, and along the posterior margins of *Bilharzia polonica* M. Kow. These "openings of the cutaneous glands" resemble very much the structures found by Nickerson upon corresponding regions of *Stichocotyle nephropis*, and interpreted by him as cutaneous sense organs on account of their connection with ganglion cells in the parenchyma. The occurrence of sexual amphitypes in a number of species of the trematode genus Opisthorchis is also noted by the author. In parasites from the same host individual the two types of sexual asymmetry occur in about equal numbers.

C. A. K.

The Corpus Luteum in the Pig and Man[2] has been the subject of careful study by J. G. Clark. The origin of this structure has been a matter of long-standing dispute, some investigators maintaining that it arose from the connective tissue investment of the egg-follicle, and others that it came from the follicular epithelium. Clark's observations are strongly in favor of its connective tissue origin. Cessation of ovulation is shown to be not due to the disappearance of egg-follicles, but to a densification of the ovarian stroma, whereby the peripheral circulation of the ovary is so interfered with that the complete formation of the follicles is hindered.

The Albatross Brachyura. — Miss Mary J. Rathbun describes (*Proc. U. S. Nat. Mus.*, XXI, 1898) the brachyurous Crustacea collected by the fish commission steamer *Albatross* during a voyage

[1] Kowalewski, M. Studya Helmintologiczne, V, *Rozprawy Wydz. mat. przyr.*, T. xxxv, 61 pp., Tab. I, II, 1898.

[2] Clark, J. G. The Origin, Growth, and Fate of the Corpus Luteum as observed in the Ovary of the Pig and Man, *The Johns Hopkins Hospital Reports*, vol. vii (1898), No. 4, pp. 181–202, 2 pls.

from Norfolk, Va., to San Francisco. In all there are 151 species, of which 31 are regarded as new. Ectæsthesius, allied to Quadrella, Lipæsthesius, Ovalipes, a new name for Platyonichus, and Tetrias, allied to Pinnixa, are the only new genera proposed. We notice the substitution of Uca for Gelasimus.

Zoölogical Notes. — The life history, habits, etc., of the tree toad, *Hyla arborea*, are exhaustively treated by H. Fischer Sigwart in *Vierteljahrschr. Naturf. Gesell. Zürich*, XXXIV, 4, 1898. The observations cover a period of about fifteen years, and he gives the dates of earliest appearance in spring, order of appearance and different organs during development and metamorphosis, color adaptation, variations, etc. One table shows by curves the relation of the loudness or quantity of the frog's song to the condition of the weather — the better the weather the louder the song.

Acalephs of the Fiji Islands are shown by Alexander Agassiz and A. G. Mayer (*Bull. Mus. Comp. Zoöl.*, XXXII, 9, 1899) to have a remarkable affinity to the forms from the West Indies. Thirty-eight species were taken, representing thirty-six genera, and with the exception of two rhizostomes all the genera are represented by Atlantic species, and in six cases specific differences could not be established between Atlantic and Pacific forms.

Ten new species of deep-sea Madreporaria are described by Major Alcock in his report on the collections of the Indian Survey steamer *Investigator*. The author points out many intimate affinities with the forms from medium depths of the North Atlantic, suggesting a sea connection in the past between the Atlantic and Indian Oceans, probably by way of the Mediterranean.

The classification of the different methods of monogenesis studied by Torrey (*Proc. Cal. Acad. Sci.*, Series 3, I, 345, 1898) in *Metridium fimbriatum*, occurring in San Francisco Bay, is as follows:

I. Longitudinal fission.
  a, equal.
  b, unequal.
    oral — aboral.
    aboral — oral.
II. Basal fragmentation.
III. Budding.
  a, pedal.
  b, œsophageal.

The paper also contains numerical data as to the relative frequency of each of these methods, and the author promises more in the future.

The circulatory system of lungless salamanders is compared with that of salamanders having lungs by Bethge (*Zeitsch. Wiss. Zool.*, LXIII, 680, 1898), who discusses the question of the seat of respiration in the lungless forms. He reaches the conclusion that the mouth, pharyngeal cavity, and integument participate in respiration to an essential extent. He thus is at variance with Marcacci and Camerano, who believe that cutaneous respiration is of little consequence.

The "cellules musculo-glandulaires" of the body wall of Owenia are reëxamined by Ogneff (*Biol. Centralb.*, XIX, February, 1899), who concludes that the structures described by Gilson do not exist. The peritoneal lining of the body cavity is closely adherent to the muscles of the body wall, but the elements do not differ from those in allied forms.

The endothelium of the heart in bony fishes, according to the recent studies of B. Nöldeki (*Zeitsch. Wiss. Zool.*, LXV, 1889), is, at least in part, of entodermal origin, but it is impossible to decide whether it all has that origin.

The eyes of annelids form the subject of the fifth part of R. Hesse's paper upon the organs for the recognition of light in the lower vertebrates (*Zeitsch. Wiss. Zool.*, LXV, 1899). Structural details of a large number of forms, as well as of physiological observations, are given.

New cestodes are described by F. Zschokke (*Zeitsch. Wiss. Zool.*, LXV, 1899) from various marsupials. The paper contains a revision of the species of Beortia and Linstowia *n. g.*

An interesting report on the "Extent and Condition of the Alewife Fisheries of the United States in 1896" has been prepared by H. M. Smith, and published in the *Report of the United States Fish Commission* for 1898. Notwithstanding the increase of catch from about 45,000,000 pounds in 1880 to about 62,000,000 pounds in 1896, the values of the catches have decreased; that of 1880 was placed at $526,000, while the catch of 1896, though one-third as large again, was worth only a little over $459,000.

Number 1 of Volume IX of the *Journal of Comparative Neurology* contains, besides the usual literary notices, the following articles:

"Observations on the Innervation of the Intracranial Vessels," by G. C. Huber; "Observations on the Blood Capillaries in the Cerebellar Cortex of Normal, Young, Adult, Domestic Cats," by F. S. Aby; "An Anomaly in the Internal Course of the Trochlear Nerve," by R. Weil; "Critical Review of Recent Publications of Bethe and Nissl," by A. Meyer; and "Report of the Association of American Anatomists," by D. S. Lamb.

We learn from *Natural Science* that Dr. Gregg Wilson points out that the lung of Ceratodus arises in the two-months-old larva as a mid-ventral diverticulum, and that the development of the pronephros is strikingly like that of urodeles.

The classification of the Coccidiidæ is treated by Louis Leger (*Am. Mus. d'Hist. Nat. Marseille*, Série 2, Bull. I, 71, 1898), who divides this family of the Sporozoa into three tribes, — Disporocysts, Tetrasporocysts, and Polysporocysts, — according to the number of spores in a cyst. Analyses of all known species are given, and also a synoptical table of genera. A number of new or little known species are minutely described and figured; all of them from arthropods, and most of them from myriapods.

The life and work of Fr. Redi, famed equally as a student of letters and of science, are the subject of a recent sketch (*Arch. Par.*, I, 3, 420, 1898). A facsimile of a handsome copperplate portrait and of a medallion, both from the collection of Professor Blanchard, accompany the article. It is rather startling to read in the bibliography of observations on parasites, and in the next sentence to see listed sonnets and dithyrambics!

Dr. H. Wallengren has published in the *Biologisches Centralblatt* an account of the conjugation of *Epistylis simulans*. He finds that the microgonidium is not wholly absorbed by the macrogonidium, the entoplasm and the nuclei alone being retained, while the shrunken ectoplasm is rejected.

The Palolo worm has been carefully studied from the taxonomic standpoint by E. Ehlers (*Göttingen Nachrichten*, math.-phys. Kl., IV, 1898). He identifies it as *Eunice viridis* Gr., and finds the formation of the palolo to be an instance of epitoke, the first observed in this family. The epitokous portions are pelagic and constitute the major part of the worm, only 250 somites out of 544, *e.g.*, being atokous. The paper includes a full discussion of the structure of both parts.

A new Bothriocephalid genus, Scyphocephalus, parasitic in Varanus, has been described by E. Riggenbach (*Zool. Jahrb.*, Syst., XII, 145, 1899). It is characterized by a deep, cup-shaped rostellum, which, however, is not primary, as in Cyathocephalus, but secondary, as shown by the long narrow grooves on the external surface, which are the reduced lateral bothria characteristic of the family. Otherwise the new genus is a true Bothriocephalid.

Tetracotyle perca fluviatilis is found by Piana (*Atti. Soc. Ital. Sci. Nat.*, XXXVII, 1898) to be present in 90–95 per cent of the fish in Varese and other Italian lakes, while in some adjacent bodies of water it was lacking. The author looks upon the species as the cause of fish epidemics there.

In Ligula, M. Lühe calls attention (*Centralb. Bakt.*, Abt. I, XXII, 7, 280, 1898) to the existence of marked external segmentation at the anterior end, very similar to that of other cestodes, though the posterior two-thirds is entirely smooth. Strangely, however, the internal structure does not correspond to the segmentation. As the larva is uniformly smooth, the segmentation of the adult must be developed in the intestine of the definite host. It may be interpreted as rudimentary, and points to the degeneration of Ligula from jointed Dibothrian ancestors that have secondarily lost their segmentation.

A statistical report on the "Nematodes Parasitic in Birds," by W. Volz (*Rev. Suisse Zool.*, VI, 1, 189, 1899), shows that hawks, fowls, and crows are most infected both in number of species and of individual parasites. Among the parasites, *Heterakis vesicularis* was the most common, occurring in nine out of twenty-three hosts examined, and *Trichosoma resectum* was found in six hosts. Only two hosts harbored as many as five species each, while the majority of both hosts and parasites manifest individual association.

Two new tapeworms of the domestic fowl from Brazil are described by Magalhães (*Arch. Par.*, I, 3, 442, 1898), *Davainea oligophora*, a minute form only 3 mm. long, and *D. carioca*.

An intermediate host of *Gigantorhynchus moniliformis* has been found by Magalhães (*Arch. Par.*, I, 3, 361, 1898) in *Periplaneta americana*. Some interesting observations on the larva of the parasite are recorded in the same article.

BOTANY.

Campbell's Evolution of Plants.[1] — In publishing his lectures on the evolution of plants, delivered at Stanford University, Dr. Campbell has done a good service not only to students of botany but also to a wide circle of readers interested in general biological problems. The book will prove enjoyable reading to persons with no more knowledge of the technicalities of botany than many high schools now afford. Teachers have long desired such a book for use with advanced pupils. At the same time it will be welcome to botanists as a broad, clear statement of the main facts of plant development and their interpretation from the most modern point of view.

After an introductory chapter, followed by one on "The Conditions of Plant Life," the author discusses in nine chapters the morphology, ontogeny, and phylogeny of the principal types of the vegetable kingdom, and finally, in three chapters, gives a rapid survey of "Geological and Geographical Distribution," the interrelations of "Animals and Plants," and the "Influence of Environment." Each chapter and the book as a whole concludes with a helpful "Summary."

The truly scientific spirit of these lectures cannot fail to exert a wholesome influence upon the students who read them. We find throughout the clearest distinction made between what is actually known and what may be more or less probable, and in weighing probabilities rival views are treated with perfect fairness. Due caution and entire frankness are most happily combined with ample freedom of the "scientific imagination."

One always feels entire confidence that Dr. Campbell's statements are not only trustworthy but up to date. In this case the impression is of a wide range of facts and ideas presented as nearly as possible in their true perspective.

FREDERICK LEROY SARGENT.

A Recent Work on Bryophytes.[2] — The first part of the second volume of Goebel's important work on the organography of plants is now before us and well maintains the high standard set by the first volume, which has already been reviewed in the *Naturalist.* The

[1] Campbell, D. H. *Lectures on the Evolution of Plants.* 12mo, viii + 319 pp., 60 figs. New York, The Macmillan Company, 1899.

[2] Goebel, K. *Organographie der Pflanzen*, Zweiter Theil, Heft 1. Jena, 1898.

second part is concerned with special organography, and the part just published deals exclusively with the Musciniæ. Goebel's extensive studies on these plants make this a most important contribution to our knowledge of the bryophytes.

The structure and development of the different organs are fully treated, but especial attention is devoted to the many adaptations to their environment exhibited by the mosses and liverworts. No botanist has done more to increase our knowledge in this direction, and the present work includes much extremely valuable and interesting matter, a good deal of which is now published for the first time.

The development of the archegonium and antheridium is first discussed, and the various devices for protecting these and the significance of their peculiar position in certain forms are treated at length. The dehiscence of the antheridium is fully described — more so than we can recall elsewhere. The most notable point in connection with the archegonium is the confirmation of the views of Janazewski and Kühn in regard to the apical growth in the archegonium of the Musci, which had been disputed by Gayet.

The various modifications of the Gametophyte in the lower Hepaticæ are described at length, and some very interesting figures are shown, especially those relating to certain tropical types like Symphyogyna and some of its allies.

The different types of gemmæ and tubers found among the liverworts are fully treated. Genuine tubers, which formerly were supposed to be absent from the Hepaticæ, are now known in several genera, including species of Anthoceros, Geothallus, and Fossombronia. The recent discovery of these in a number of liverworts from California and South America indicates that these structures probably occur in a good many species of dry regions. Descriptions and numerous figures of the contrivances for storing water, such as the sac-like organs in the leaves of many tropical Jungermanniaceæ, are given. As might be expected from the careful study of these which the author has made before, the subject is given very thorough treatment.

The various types of sporophyte found among the Hepaticæ are described and figured, but this section of the work does not include much that is new.

As might be expected, the Musci are given less space than the much more generalized and varied Hepaticæ. The more aberrant types, like Schistostega, Sphagnum, and Buxbaumia, are considered somewhat at length. The latter Goebel is still inclined to consider

as a primitive type, although many botanists will be inclined to consider it as a degenerate rather than as a primitive form.

Of the different types of sporogonium among the Musci the peculiar genus Nanomitrium is interesting as showing very marked similarity in the arrangement of its parts to that of the typical liverworts. In this moss most of the endothecium appears to be composed of sporogenous tissue. Whether this genus, and the similar Archidium, are really primitive types, as Leitget supposed, or are related to the typical Bryineæ, remains to be seen.

The book is fully illustrated and includes many new figures. It is certainly a most important contribution to the literature of the archegoniate plants.

D. H. C.

Aldehyde in Leaves.[1] — The formation of an insoluble "hydrazone" on the addition of metanitrobenzohydrazide to a solution of an aldehyde was taken as a means of the quantitative estimation of the latter substance in green leaves. Previously it has been shown by qualitative tests that a "leaf aldehyde" (Blätteraldehyd) is found in many plants. The quantity present seems to vary within wide limits; the conditions influencing its formation are not understood. From the experiments it appears that leaves kept in continued darkness show a decrease in the amount of aldehyde present, but by no means all of it disappears under such conditions. The bearing of this fact on the suggestions that some form of aldehyde is the first product of photosynthesis are, however, not distinct at present. But while nothing has been shown which proves that such a substance may be the initial carbohydrate formed, it is a matter of interest that the aldehyde can be utilized by the plant as a food substance, and such certainly seems to be the case. It would be of especial value, however, to know something of the relation which exists between the disappearance of starch in the absence of light and the partial use of the aldehyde under similar conditions. One might then be able to conclude whether it is due to the exhaustion of other reserve material that the plant is perforce necessitated to utilize the aldehyde, or whether it exercises any selective power in this regard. The writers do not maintain that the aldehyde is to be regarded as the first assimilation product, — in fact they directly state that it is to be regarded as a by-product; but it is hard to agree with them that had

[1] Reinke, J., and Braunmüller, E. Untersuchungen über den Einfluss des Lichtes auf den Gehalt der grünen Blätter an Aldehyd, *Rev. d. deut. Bot. Gesel.*, Bd. xvii, Heft 1, p. 7.

a complete disappearance of this substance been shown by the experiments, conclusive proof would then have been afforded of the primary nature of the aldehyde. H. M. R.

Light and the Respiration of Fungi.[1] — By a series of carefully arranged experiments, chiefly with *Aspergillus glaucus* and Penicillium, it is shown that the action of light increases (*circa* 10 per cent) the respiration of these fungi, and that this increase is independent of the food supply and of the morphological condition of the culture. As the author says, this increase, though not great, is quite contrary to what our knowledge of these forms would lead us to expect. He refrains from drawing any conclusions from the present data, evidently purposing to pursue the matter further. The results recorded are noteworthy and, if supported by further ones, are of considerable importance. H. M. R.

Spore Development in the Hemiasceæ.[2] — Two forms of this heterogeneous group are considered in detail as to their spore development. These are Ascoidea and Protomyces. In the former it appears that the spores when ripe lie in a mass of protoplasm analogous to the condition generally found among the Ascomycetes, but the multinucleate condition of the ascus and the behavior of these contained nuclei do not seem to correspond to the observations recorded in the late researches on this last-named group. In Protomyces, on the other hand, the spores do not lie imbedded in a mass of unused protoplasm, but are free within the remnant of the protoplasmic sac which still adheres to the wall of the sporangium. This condition the author regards as more nearly akin to that found in the Phycomycetes. The result of the observations seems to show that these two members of the Hemiasci, aside from their radical dissimilarity in other ways, are not closely related in the matter of spore formation. This it will be noticed does not agree with the arrangement of these forms adopted by Brefeld, but to the average observer who has seen Protomyces, points of similarity of that form with the phycomycetous fungi are not surprising. H. M. R.

A New Work on Lichens. — Lieferung 180 of *Die natürlichen Pflanzenfamilien* forms the first portion of Fünfstück's account of the

[1] Kolbswitz, R. Ueber den Einfluss des Lichtes auf die Athmung der niederen Pilze, *Prings. Jahrb.*, Bd. xxxiii, Heft 1, p. 123, 1898.

[2] Canna, M. L. Popta. Beiträge zur Kenntniss der Hemiasci, *Flora*, Bd. lxxxvi, Heft 1, p. 1, 1899.

Lichenes. From this a few general statements are culled which may be of interest to non-lichenologists. The literature of lichens is very extensive, that here cited covering three closely printed pages. With very few exceptions lichens are of slow growth and long life, several decades being required by some alpine sorts to reach maturity and fructification. The greater number occur on rocks, but many are found on tree trunks, dead wood, or on the earth. Only a few sorts grow under water (Verrucaria sp.). It may be assumed that nearly every one knows that lichens are symbiotic growths. It is now just thirty years since the publication of Schwendener's memorable paper, and the matter was fought over and settled in the seventies. In different lichens the relation between the fungus and the alga is very different. In Physma, Arnoldia, and many other genera the algal cells are destroyed by the fungus, haustoria being sent through the algal membrane into the plasma. In other lichens, such as Micarea, Synalissa, the haustoria bore through the algal membrane but do not penetrate into the plasma. As a rule the algal cell is entered by only one haustorium. Finally, in many lichens, *e.g.*, those with Protococcus gonidia, the relation of the two components is only one of intimate contact, the fungus causing no visible change either in the membrane or in the contents of the algal cells. The manner of union of fungus and alga is very constant in any given species of lichen, and it is usually the fungus which determines the form of the lichen. According to external form, lichens may be classified as bushy, leafy, or crustaceous. Formerly much use was made of these distinctions for purposes of classification, but this system has now been abandoned, as separating closely related forms. Classification is now based largely on the ascospores. For anchorage and food absorption lichens are united to the substratum to very different degrees. The most intimate union is that of crustaceous, calcivorous species — Verrucaria, Staurothele, Thelidium, etc. The hyphæ of some of these species penetrate into the stony substratum in all directions, to a depth of ten to twenty millimeters or more. On the other hand, the Collemas, etc., only rest their gelatinous masses on the substratum without producing any visible change in it. Between these extremes are various intermediates. Even the hardest rocks are eroded by lichens. *Lecanora polytropa* offers a striking example of this, the hard gneiss rock to which it adheres being eroded into cavities exactly the size and shape of the lichen crusts which occupy them. In most lichens the algal elements are confined to a particular zone, but in some sorts the algæ are

uniformly distributed through the body of the thallus. This difference has little systematic value. With few exceptions, some of which are still disputed, the lichen fungi all belong to the Ascomycetes. The lichen algæ belong to the Schizophyceæ and Chlorophyceæ. Rarely filamentous forms occur. The various lichen fungi have not been found growing free except in case of a few Basidiolichenes, and some saprophyte Ascomycetes which occasionally form so-called "Half-lichens"; but in a number of cases they have been cultivated free. Many, if not all of the lichen algæ, are also believed to occur free in damp places, but owing to changes in shape and size, brought about by the presence of the fungus, there is still much uncertainty respecting the identity of the algal element in the thallus of many lichens. Quite a number of these algæ have been cultivated independently of the fungus, and ten species found in lichen thalli have been definitely identified as well-known species occurring independently of fungi. These belong to as many different genera. Almost always each species of lichen is adapted to one species of alga, but sometimes accessory species of algæ are present in the thallus, forming in connection with the lichen-fungus growths called cephalodia. The fungus provides the imprisoned alga with water and inorganic foods. It loses nothing itself by this symbiosis and gains the ability to live on bare rocks and other most resistant surfaces. What benefit the algæ derive from such unions is problematic. In the lichen thallus they are said to reach a larger size and to divide more rapidly than outside; they are also able to live and work in places otherwise unsuitable. On the other hand, they have very generally lost the ability to produce swarm spores, a function soon regained on cultivating them free from the fungus. The lichen attacks the rocks by means of acid excretions which the fungus alone appears to be unable to produce. More than sixty acids have been isolated and described, and the chemistry of the group is complex. The reproduction of the group, aside from mere vegetative propagation by soredia, which is very common, is that of the fungus. Oidial, or chlamydospore, fructification has been found only in Caliceæ. Free conidial fructification, so common in the Ascomycetes, has been found only in two lichens. Pycnidia, on the other hand, are common. The highest form of fructification is by means of ascospores. In some lichens this form is wanting, or at least has never been found. Basidiospores are said to occur in the tropical genera Cora and Corella. According to the author it is exceedingly probable that even in Collema there is no sexual reproduction. Lichens are often

brilliantly colored, browns, grays, and yellows preponderating. They are very rich in variety of forms, but these seldom resemble the separate growths of either component. Nearly 20,000 species, varieties or forms of lichens, have been described, but only about 4000 are well known. Lichenes are distributed over the whole earth. They occur farthest north and farthest south, and highest up on mountains of any plants. They are resistant to heat and to cold. Hot countries are relatively poor in species. In the Torrid zone they are found mostly on trees. The outer fungus rind is thin in the shade and thick in the sun. In hot, dry countries all the lichens have a common habit (Australia, Cape of Good Hope, Chili). Cold countries, especially in the northern hemisphere, are richest in species. Many species are widely distributed. Very few are edible. Among the latter, perhaps the most interesting is the rapidly growing manna lichen, known to the Tartars as earth bread, and a variety of which (*Lecanora esculenta* var. *jussufii*), easily blown about by the wind, and then known as "rain manna," is perhaps the manna of the Israelites.

ERWIN F. SMITH.

Agardh's Algæ.[1] — It is not often that an author, fifty years after the issue of the first part of a work, is, like Professor Agardh, still continuing its publication. Nor does this fifty years by any means cover the time during which the name of Agardh has been among the foremost in algological science. The elder Agardh, father of the present author, was already publishing his observations quite early in the present century, and in 1823 he issued the first volume of his *Species Algarum*, intending to include in the work all the species known at the time. It remained unfinished, but it marks a distinct advance in systematic algology.

Its author had the valuable faculty, in arranging a genus or group of higher rank, of seeing clearly the really distinctive characters and using them as a basis of classification. This faculty appears in even a higher degree in his son, J. G. Agardh, and for many years his *Species Algarum*, of which the first volume was published in 1848, has been the standard, especially as to the red algæ. It is only within the last three or four years that an arrangement of the red algæ, differing seriously from Agardh's, has been presented and has met with any general acceptance. The arrangement of Schmitz, as given by Engler and Prantl, is based on the details of the fertilization

[1] Agardh, J. G. *Species, Genera, et Ordines Algarum*, voluminis tertii, pars tertia. De dispositione Delesseriearum curae posteriores. Lund, 1898.

and its results, instead of on the structure of the mature cystocarp, as was Agardh's scheme. Schmitz's plan has the disadvantage that the data for its application are known in only a small proportion of the algæ; the great majority have to be assigned their place by analogy with the few of which it has been possible to study the development thoroughly; and already new observations threaten to reopen what Schmitz considered settled questions.

Agardh's system was more convenient, in that we knew the cystocarps of much the greater part of the red algæ, and might reasonably hope to find cystocarps in the few species where they were still unknown. But the chance is small of an opportunity to follow the stages from trichogyne to cystocarp in an alga from some remote part of the world, of which only a few specimens are known, and those washed up from deep water.

The present section of the work is devoted to a review of the Delesseriaceæ, of which the known species have much increased since the publication of part one of the volume in 1876. The limitations of the family are the same as before, but the subdivisions are changed, and several new genera are founded at the expense of the old genera Nitophyllum and Delesseria. The cystocarpic fruit is practically the same in all, and the characters of the tetrasporic fruit are used only for specific distinctions; all the species have the form of a flat membrane, and the distinctions are made by the greater or less number of layers of cells, the difference in size or shape of the cells of the different layers, and the presence or absence of raised mid and lateral ribs, or of veins, not elevated but formed by cells of distinctive form. Several new American species are described from Florida and from the Pacific coast.

We are sure all algologists will join in the hope that this, the latest in the author's long series of contributions, will not be the last.

F. S. COLLINS.

Greenland Algæ.[1] — It is a rather curious fact that there is hardly any part of the American coast with whose algæ we are as well acquainted as we are with those of Greenland. A number of investigators have contributed to our knowledge of this region, but much the largest share is due to the author of this work. In a former work on the same subject[2] he gave what seemed a very full account

[1] Rosenvinge, L. Kolderup. Deuxième Mémoire sur les Algues Marines de Groenland, *Meddelelser om Groenland*, XX. Copenhagen, 1898.

[2] Groenlands Havalger, *Meddelelser om Groenland*, III, 1893.

of the marine flora of the region; but the present paper, besides contributing much to our knowledge of species already found there, adds twenty-four, of which seven are new to science. This brings the total of species to 167; and if we compare this number with the corresponding figures for other regions, it must be borne in mind that the author, perhaps more than any other algologist, defines species in a very broad way, often including under one specific name several forms that are elsewhere considered distinct.

Even without this allowance, however, the number must be considered very high for an arctic flora. Two causes have contributed to increase the number — the careful study of minute epiphytic and parasitic forms, and knowledge of deep-water forms obtained by extensive dredging.

Like its predecessor, the paper is illustrated by figures in the text; the latter is in French, however, instead of Danish; a change that will be regarded as an advantage by its readers, unless they are ultra-patriotic Danes.

F. S. COLLINS.

Botanical Notes. — The localization of the alkaloid in Cinchona has been investigated by Dr. Lotsy, whose studies of Taxodium are familiar to American botanists, and who is now connected with the laboratories which the Dutch government has established in its Indian colonies, for the investigation of the quinine-producing trees. His conclusions form No. 1 of the laboratory contributions of the *Gouvernement's Kinaonderneming*, printed at Batavia, a quarto of 128 pages, containing two folding plates and accompanied by an atlas of twenty colored plates of larger size.

Professor W. W. Bailey, of Brown University, communicates the following observations upon a South African species, in which proterandry was previously recorded by the same author in 1886.

"I have had a plant of *Veltheimia viridifolia* for some twenty years, and this year, after a long interval, it is blooming. The flowers, each of which has a long period of anthesis, are proterandrous, the stamens preceding the pistils several days in their development. They are slightly exserted, and the style, when finally it appears, is long exserted. The perianth is withering-persistent, and the raceme of some twenty or thirty flowers is over a month in blooming — perhaps two months in the development of its foot-long scape."

Boerlage's *Flora van Nederlendsch Indië*, with Part II of the second volume, recently issued, completes the Gamopetalæ, including the families Oleaceæ to Plantaginaceæ.

The *Bulletin* of the Torrey Botanical Club for March contains a revision of the United States species of Dolicholus (Rhynchosia), by Miss Vail; notes on some new and little known plants of the Alabama flora, by Dr. Mohr; new plants from Wyoming, by Professor Nelson; some new species from Washington, by K. M. Wiegand; and Part XXVI of the enumeration of the plants collected by Dr. H. H. Rusby in South America, 1885–86.

Part II of the current volume of *Minnesota Botanical Studies* contains articles on a considerable range of botanical subjects, among which are one or two of morphological and physiological value.

Professor Nelson tells in *Bulletin No. 40* of the Wyoming Experiment Station about the trees of that state. Characters of easy application are employed for their ready determination.

The newly begun *Comunicaciones* of the Museo Nacional of Buenos Aires contain articles by Spegazzini descriptive of South American phanerogams.

To students of the ecological phases of plant distribution an article by Jaccard on "La Flore du Haut Bassin de la Sallanche et du Trient," in the *Revue Générale de Botanique* for March 15, will prove of interest.

Anemone, the "wind-flower" of most persons, is said, by C. H. Toy, in *Rhodora* for March, to be really the flower of Na'mān — another name for Adonis, from whose blood the red anemone is supposed to have sprung.

Anemone riparia, a large-flowered, slender-fruited form of the northern Atlantic region, is separated from *A. virginiana* and *A. cylindrica* by M. L. Fernald in *Rhodora* for March.

Epilobium obcordatum and *Ceanothus integerrimus*, of California, are figured in the *Botanical Magazine* for February.

Viburnum lantanoides, which is commonly described as of irregular or straggling habit of growth, is shown by Dr. Ida Keller to have a decided tendency to the sympodial method of branching. — *Proc. Phila. Acad.*, 1898.

Cirrhopetalum robustum, a new Guinea orchid, is said, by MacMahon, in the *Queensland Agricultural Journal* for January, to be a good example of a carrion plant. Its flowers are pollinated by blue-bottle flies by aid of a very ingenious mechanism.

To the *Journal* of the Elisha Mitchell Scientific Society for 1898 Mr. W. W. Ashe contributes a paper on the dichotomous group of Panicum in the eastern United States. Seventy-four species — a considerable number of them new in the belief of the author — are described.

Biological notes on Indian bamboos are contributed to the January number of *The Indian Forester* by Sir Dietrich Brandis.

The toxic effects of sleepy grass, *Stipa robusta*, are being discussed by the medical and pharmaceutical press. The *Bulletin of Pharmacy* for March contains an interesting résumé of some of the recent observations.

In Nos. 8 and 9 of his "Studies in the Cyperaceæ," reprinted from recent numbers of the *American Journal of Science*, Mr. Holm treats of the genera Scleria and Lipocarpha.

Evergreens, and how they shed their leaves, is the title of *Teacher's Leaflet* No. 13, of the College of Agriculture of Cornell University.

The histological generic characters of the North American Taxaceæ and Coniferæ are well presented by Professor Penhallow in a paper reprinted from the *Transactions* of the Royal Society of Canada.

Even greenhouses, when at all extensive, have their own spontaneous flora. In the *Verhandlungen des Botanischen Vereins der Provinz Brandenburg* for 1898 P. Hennings enumerates a considerable number of fungi observed in the plant houses of the Berlin botanic garden, and finds not a few of them new to science. In *Rhodora* for May, M. Hollis Webster also publishes a similar article, dealing with fungi observed in the United States.

Collecting and preserving marine algæ, a subject of interest to every visitor to the seashore, is treated at considerable length by Professor Setchell in *Erythea* for March.

Berg und Schmidt's Atlas der Officiellen Pflanzen, of which a second edition is being issued under the care of Drs. Meyer and Schumann, has completed the third volume, which contains Pls. XCV–CXXXII.

In the *Pharmaceutical Journal*, beginning with the issue for February 25, Mr. F. Ransom is publishing a series of articles on the origin and meaning of the names of medicinal plants — these being arranged in the familiar sequence of Durand's Index.

GEOLOGY.

Rivers of North America.[1] — A book with the comprehensive title *Rivers of North America* cannot fail to arouse interest among students of nature, especially when followed by the name of the author, Professor Israel C. Russell. Curiosity is felt as to how a subject so vast as this can be concisely treated by any writer, particularly by one who has obtained many of his conceptions at first hand through observation and study in the field. Of the many ways in which the rivers of North America might be discussed there occur to the mind two as especially distinct and important. The first is a geographic description of the position, length, volume, character of water, and other existing conditions; and the second might be an analysis from the geologic standpoint of the causes of these features or of the phenomena as noted along the course of each river. This latter form of treatment is that toward which Professor Russell has directed most of his investigations, and the book reflects largely the results of his field work. In fact his book might be classed as a primer of hydro-geology or hydrology, using this latter term as distinct from hydro-geography (hydrography), or the description of bodies of water. The hydrographic or descriptive part of the subject is not neglected, being included under the head of "Characteristics of American Rivers," but is subordinate to the thorough discussion of the why and wherefore of present conditions.

Professor Russell begins by showing that the surface of the earth is a scene of continuous change, the higher portions being gradually worn away and modified by the running waters, which, gathering into streams, make for themselves valleys proportioned to the various forces at work. Beginning with rock decay and removal of the surface débris, he passes on to discuss the laws governing streams, the limitation of downward cutting to base level, the influence of the hardness of the rock in producing rapids and waterfalls, and makes note of the material carried by the streams in visible particles or in solution. Passing from the destructive or eroding action of the rivers, he takes up their constructive features and shows how the alluvial cones and deltas grade from one into the other, and brings out the origin of the stream terraces, developing the fact that these, from the industrial standpoint, are among the most important resultants in the development of the country, since they furnish some of

[1] Russell, Israel C. *The Rivers of North America.* xix + 327 pp., 17 pls., 18 figs. New York, Putnams, 1898.

our best farm lands. Following this description of down-cutting and up-building, he brings out the effect of changes in the earth's crust by elevation and subsidence and by variations in climate, particularly through glacial action, and then having touched upon the principal points of hydrology he gives, as above noted, some of the characteristics of important streams, and, in conclusion, takes up the life history of a river, showing the principal events from youth to old age.

The conception is constantly kept before the reader that a river is a living thing working out its own life history, and that the apparently permanent features which we see are the temporary products of a restless and moving organism. The converse is also enforced that for every delta, terrace, curve, rapid, or fall of the river there is a definite cause, which may be sought and explained according to general law, and that the apparent anomalies may be reconciled if the student will patiently look into the subject.

The discussion of these natural laws, while necessarily somewhat abstruse, is rendered as interesting as possible by copious illustrations taken from well-known phenomena in the geography of North America. For example, as showing the importance of the glacial epoch upon the industrial development of New England, it is stated that manufactures were established there soon after the coming of Europeans, owing to the facilities offered by the numerous small water powers. These resulted from the disturbance produced in stream development by the débris left by the retreating ice sheet of the past geologic age. South of the glacial boundary, that is, south of Pennsylvania, water power is far less abundant and mostly within the inaccessible portions of the mountains. The development of manufacturing industries hence has been delayed and attention given more largely to agriculture, for which climatic and other conditions are more favorable. Thus a decided trend was early given to the New England character and manufacturing was so firmly established that although the water powers have relatively declined in importance, and steam has usurped their place, yet the glaciated regions of the United States still continue to lead in manufacturing. Here we have a direct relation between the effects of ancient changes in geography and modern growth of civilization.

Another striking illustration of the effect of geologic changes upon industrial development is given in the case of the drowned river — the Hudson — whose valley submerged by subsidence of the earth's crust has become a long narrow arm of the sea, where the tides rise and fall. During its early history the river cut its deep channel

across a mountain range as it was slowly being elevated, and continued its course far out into what is now the present ocean, to a point at least eighty miles eastward of Long Island. In late geologic time a downward movement of the earth's crust, too insignificant to be noticed in comparison with the whole diameter of the earth, has brought the former mouth of the river below sea level, and the salt water gradually encroaching has filled the broad valley where now is the important harbor of New York, and has made possible ocean navigation far inland. The influence of this easy route of communication up to the site of the present city of Albany, and from that point by easy paths up the broad Mohawk to the Great Lakes, determined the history, not only of New York State, but of the people of the continent, and has resulted in making this state the richest of the American Union.

F. H. NEWELL.

PETROGRAPHY.

The Volcanics of San Clemente. — San Clemente Island, off the coast of Southern California, is built up[1] almost exclusively of lava flows, volcanic breccias, and ash deposits. The principal eruptive is a pyroxene-andesite. In addition to this, there are smaller areas of rhyolite and dacite. The andesite consists of a mediumly basic plagioclase, augite, often hypersthene and magnetite as phenocrysts in a ground mass composed of the same minerals, with a larger or smaller proportion of glass. The dacite lies above the andesite, and the rhyolite above the dacite. The former rock contains the same phenocrysts as the andesite, but in the ground mass there is considerable quartz intergrown with oligoclase in micropoicilitic patches, and a large quantity of orthoclase, likewise in micropoicilitic intergrowths with the same plagioclase. The quartz and orthoclase appear to form the matrices in which laths of the plagioclase are imbedded.

The rhyolite is of an unusual type. It comprises phenocrysts of andesine, a few of hypersthene and magnetite, and an occasional one of augite in a microgranular and glassy matrix. The crystalline portion of the matrix is composed of quartz, orthoclase, and andesine, forming bands and lenses separated from one another by bands of glass.

[1] Smith, W. S. T. *Eighteenth Ann. Rep. U. S. Geol. Survey, 1898*, Pt. ii, p. 459.

The approximate composition of the rhyolite (I) and of the andesite (II) is as follows:

	SiO_2	Al_2O_3	Fe_2O_3	FeO	CaO	MgO	Na_2O	K_2O	Ign.	Tot.
I.	70.39	14.09	.53	2.12	3.08	.62	3.70	3.51	2.50 =	100.54
II.	66.85	14.08		3.06	4.69	.91	3.80	2.57	2.07 =	98.03

Contact Phenomena in Michigan. — Between the graywackes, slates, etc., of the Mansfield formation, in the Crystal Falls district of Upper Michigan, and a mass of diabases on their flank, is a contact zone of dense hornstone-like rocks that have been studied by Clements.[1] As the intrusives are approached the graywackes and slates are changed into spilosites, desmosites, and finally adinoles.

The unchanged clay-slates are banded rocks composed of quartz, muscovite, rutile, hematite, and an occasional needle of actinolite in a mass of feldspathic dust. With these are phyllites, which differ from the slates in being richer in muscovite, and in containing no feldspathic interstitial substance. The contact rocks consist of quartz, albite, biotite, chlorite, muscovite, actinolite, rutile, epidote, and iron oxides. The spilosites are mottled, the spots usually being richer in chlorite than the surrounding matrix. In the few instances in which the spots are lighter colored, they are composed predominantly of feldspar. The desmosites are like the spilosites, except that the spots are united into bands. In the adinoles actinolite is the chief colored constituent, while in the spilosites and desmosites chlorite plays this rôle. The chemical relationships existing between the unchanged and the altered rocks are shown by the following analyses (in addition to the constituents indicated below there are also indicated in the original small quantities of others):

	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	CaO	MgO	K_2O	Na_2O	H_2O	P_2O_5	C
I.	60.28	.69	22.61	2.53	.45	.13	1.35	5.73	.54	4.22	0.3	.97
II.	52.51	1.70	19.00	3.31	7.19	1.55	3.29	.70	6.72	3.60	.15	
III.	57.77	.92	19.35	1.29	3.37	1.71	4.35	.22	8.22	2.52	.04	
IV.	74.16	.37	11.85	.82	1.66	2.10	2.10	.15	6.57	.57	.09	

I = slate, II = spilosite, III = spilosite, IV = adinole.

Silica increases as the igneous rock is approached, and alumina and the iron oxides decrease. Moreover, the potassa, which is the predominant alkali in the unaltered slate, is replaced almost completely by soda in the altered forms. The clay-slate is clearly clastic; the altered rocks are entirely crystallized. The former contains no albite, while the latter are rich in it. It appears that, in

[1] *Amer. Journ. Sci.*, 1899, p. 81.

the change from the slate to the adinole, an actual addition of material from the igneous rock has taken place.

The Granitic Rocks of the Sierra Nevadas.—Turner[1] describes the granular complex of the central and southern Sierra Nevadas as comprising nearly the entire range of plutonic rocks. They are associated more or less closely with gneisses, some of which may be sedimentary while others are igneous. Among the rocks belonging in the granite family the author distinguishes seven types, a biotite granite, a granodiorite, a quartz monzonite, both in porphyritic and in non-porphyritic phases, soda-granite, aplite, potash-aplite, pegmatite, and a type designated as the bridal veil granite.

The granodiorites constitute a portion of a huge batholite, the parts of which have been differentiated into quartz-diorites, quartz-mica-diorites, quartz-hornblende-diorites, and quartz-pyroxene-diorites, gabbros, and olivine-gabbros. Typical granodiorite is an aggregate of plagioclase (usually andesine), quartz, orthoclase, and either biotite or amphibole, or both. The quartz-monzonites contain oligoclase instead of andesine. They are more acid than the granodiorites, as shown by the analysis below. The bridal veil granite is a fine-grained white rock that often possesses an orbicular structure — the nodules consisting of a white nucleus of quartz and feldspar surrounded by a zone rich in biotite.

The aplites and soda-granites are also white rocks in which albite is the principal feldspathic component. Quartz-diorite aplites occur in dykes cutting quartz-diorite. These are regarded as genetically connected with the more basic diorite with which they are associated, just as the potash aplites are related to the granodiorites and quartz-monzonites in which these rocks occur. The feldspar of the quartz-diorite aplite is chiefly andesine.

Analyses of the most important types of rocks discussed are shown in the following figures:

	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	CaO	MgO	K_2O	Na_2O	H_2O	P_2O_5	Tot.
I.	70.75	.29	15.51	.85	1.34	2.82	.55	4.28	3.11	.46	.10	= 100.34
II.	65.48	.52	16.05	1.47	3.06	4.88	2.13	2.43	3.49	1.27	.12	=
III.	66.83	.54	15.24	2.73	1.66	3.59	1.63	4.46	3.10	.56	.18	= 100.82
IV.	74.21	.30	14.47	.35	.50	1.71	.28	.10	7.62	.38	.07	= 99.99
V.	69.66	.21	17.57	.21	1.04	4.54	.58	.71	4.91	.55	.03	= 100.09
VI.	76.00	.08	13.23	.54	.35	1.38	.09	5.40	2.74	.43	.02	= 100.37

I = average of three biotite-granites, II = average of five granodiorites, III = quartz-monzonite, IV = soda-aplite, V = quartz-diorite aplite, VI = average of two potash-aplites.

[1] *Journ. of Geology*, vol. vii, p. 141.

The totals include small amounts of MnO, SrO, BaO, and other oxides.

The Rocks of Mount Rainier. — The volcanics of Mount Rainier[1] are basaltic and andesitic lavas and tuffs, passing into one another by almost imperceptible gradations. The predominant andesite is hypersthenic, but other pyroxenes often occur with the hypersthene and sometimes replace it entirely in the rock mass. The platform upon which the volcanics were extruded consists of a granite either hornblendic or biotitic.

Luquer's Minerals in Rock Sections[2] is an attempt to furnish to students in as few words as possible an account of the practical methods of identifying the minerals occurring in rocks by means of their optical and other physical properties as they may be observed in thin sections under the microscope.

The general principles of optics are discussed in the first thirty-four pages of the book as an introduction to the description of the characteristics of the individual minerals. Unfortunately, this discussion is so condensed that it can afford no help to the student unless it is accompanied by explanatory lectures. As a summary of a course of lectures in optics it might possibly be of value. The discussion explains nothing; it is merely a dogmatic statement of facts, sometimes so bare of explanatory or illustrative phrases as to leave only a confused impression in the mind of the reader. This is particularly noticeable in the case of the definitions. For instance, the first time the term "extinction angle" is used, it is described as the angle between the axis of elasticity and the crystallographic axis, without reference in any way to the fact of extinction. There is much loose expression in this part of the book, which, of course, might easily be corrected in a new edition.

The chapter on the microscopic features of the individual minerals covers forty-five pages. Here we find a very concise description of the principal diagnostic characters of the minerals most frequently found in rocks, with brief remarks on their occurrence.

A noteworthy feature of the volume is the clear manner in which directions are given for the manipulation of the apparatus employed

[1] Smith, G. O. *Eighteenth Ann. Rep. U. S. Geol. Survey*, Pt. ii, p. 416.

[2] *Minerals in Rock Sections.* The practical methods of identifying minerals in rock sections with the microscope. By L. McI. Luquer, C.E., Ph.D. vii + 117 pp., 48 figs. Price $1.40. New York, D. Van Nostrand Co., 1898.

in the investigation of the optical constants. The methods described, while simple, are those in most use among practical petrographers. Some of them are here given for the first time in English text.

Though the book has some faults, some of them serious ones in a student's text-book, it will unquestionably be of service as affording a convenient summary of lecture courses. It is also a good note-book on the microscopical characters of minerals.

The Fuess Catalogue.[1] — The author, who for several years has directed the optical section of the Fuess establishment, has here given a complete description of all the Fuess instruments made for optical or allied purposes, including, therefore, spectro- and refracto-meters and spectro-photographic apparatus, goniometers, polaniscopes and microscopes, section-cutting machinery, heliostats, and projection and micro-photographic apparatus. The work is really a text-book for the principles of construction, use, and adjustment of these instruments, and contains numerous additional references to the literature of the subject. The abundant illustrations elucidate the text.

Petrographical Notes. — Patton[2] notes that mica-schists in contact with pegmatite veins on the Belcher Hill road between Golden and Central City, Colorado, are impregnated with tourmaline to a very great extent. Sometimes the tourmaline is noticed in the cleavages of the schist, when the resulting rock is a banded or laminated one. Where the contact action was more severe the tourmaline is in streaks, which, however, bear no definite relation to the original cleavage direction of the schist, which in many cases has been obliterated. The tourmalinized schists are composed of quartz and muscovite, in addition to the tourmaline, while the schists that have not been impregnated with tourmaline contain an abundance of biotite. The tourmaline, as seen in thin section, is discovered to be full of quartz inclusions, and to enclose here and there small grains of rutile or zircon. The pegmatite veins that are supposed to have caused the alteration in the schists are thought by the author to be segregation veins.

Kemp[3] is continuing his studies on the geology of Essex County, N. Y. In a recent report he describes briefly the rocks of the town-

[1] Leiss, C. *Die optischen Instrumente der Firma R. Fuess, deren Beschreibung, Justierung, und Anwendung.* 233 figs., 3 plates. Leipzig, W. Engelmann, 1899.

[2] *Bull. Geol. Soc. Amer.*, vol. x, p. 21.

[3] *Fifteenth Ann. Rep. State Geologist* (New York), p. 575.

ships of Chesterfield, Jay, Wilmington, St. Armand, North Hudson, Schroon, Ticonderoga, Minerva, and Newcomb. Gneisses, gabbros, and anorthosites are the most interesting of the rocks mentioned. The latter exhibit beautifully the effects of dynamo-metamorphism.

In the Lake Placid district in Essex County, in addition to the rocks above mentioned, Kemp[1] finds limestones, quartzites, and granites. The geology of the district is described popularly in a small pamphlet, which is accompanied by an excellent map.

[1] *Bull. New York State Museum*, vol. v, No. 20, p. 52.

NEWS.

THE New England Botanical Club has just issued its neatly printed club-book for 1899, containing the constitution of the club, list of the officers, members, and personnel of its various committees. There are now forty-four resident members (those living within twenty-five miles of Boston), and forty-two non-resident. It is evident from the list that the club already includes nearly all the publishing botanists who are engaged in the investigation of the New England flora.

After the close of Vol. II the *Zoölogical Bulletin* will be continued under the name of *The Biological Bulletin*, and will be published under the auspices of the Marine Biological Laboratory at Woods Holl, Mass. The journal will be enlarged to include general biology, physiology, and botany; and it will contain occasional reviews and reports of work and lectures at the Marine Biological Laboratory.

Brighton, England, is to have a new zoölogical garden.

Mr. Georges Clautrian, of Brussels, receives a prize of 600 francs from the Belgian Academy, for his researches in the chemistry of digestion in carnivorous plants.

We note the statement in a recent number of *Natural Science* that the gypsy moth is rapidly disappearing from England, and in certain localities it is no longer to be found. Possibly they have emigrated, attracted by the generosity of the Massachusetts Legislature.

The Egyptian government is to begin a scientific study of the fishes of the Nile, the work being done by English naturalists.

Falcon Island, near the Tonga group, has disappeared after an existence of thirteen years. It was found as a volcanic upheaval. In this connection we note a submarine eruption in March, causing a "tidal wave" which did great damage in the Solomon Islands.

A sketch of the life of the late James Hall, with a presumably complete bibliography of his scientific writings, appears in the March number of the *American Geologist*.

Mr. J. Stanley Gardiner has been appointed Balfour student of the University of Cambridge. The studentship is for three years and has an annual value of £200. It is designed for research in the line of animal morphology.

Mr. W. W. Skeat, accompanied by Messrs. Evans and Aumandale as zoölogists, and Mr. Gwynne-Vaughan as botanist, goes to the Malay peninsula to make investigations upon its natural history. The expedition is aided by the University of Cambridge.

The Belgian Royal Academy has awarded a prize of 600 francs to Professor L. Cuénot, of Nancy, France, for his studies of the nephridial system of the molluscs.

The *Concilium Bibliographicum* announces their new address to be 38 Eidmattstrasse, Zürich-Neumünster. The new house contains a press room in the basement, offices, storerooms, and composing rooms in two upper stories. Dr. J. Dewitz has been appointed resident assistant and Dr. L. Lalry correspondent.

The board of estimate and apportionment for the City of New York has set aside $63,000 for the zoölogical garden in Bronx Park. It is also proposed to raise the appropriation for the American Museum of Natural History from $90,000 to $130,000 a year.

Dr. Adolph Fick, professor of physiology in the University of Würzburg, has resigned at the age of seventy years.

Several graduate fellowships and scholarships in scientific departments are vacant this spring at the University of Nebraska. Holders of these positions are expected to give a certain portion of their time to assistance in the department in which they are working.

Appointments: Vidal de la Blache, professor of geography in the University of Paris. — Mr. Joseph Barrell, instructor in geology and lithology in Lehigh University, South Bethlehem, Penn. — G. Gilbert Cullis, assistant professor of geology in the Royal College of Science, South Kensington, London. — Ulric Dahlgren, assistant professor of histology in Princeton University. — Dr. William Morris Davis, Sturgis-Hooper professor of geology in Harvard University. — A. W. Hill, demonstrator in botany in the University of Cambridge. — Dr. Moritz Hoernes, professor extraordinarius of prehistoric archæology in the University of Vienna. — Dr. Robert Tracy Jackson, assistant professor of paleontology in Harvard University. — Dr. Bengst Jöhns-

son, professor of botany at the Akademie at Lund, Sweden. — Dr. Adalar Richter, professor extraordinarius of botany in the University of Klausenburg. — Mr. W. E. D. Scott, curator of the ornithological collections of the Green School of Science in Princeton University. — Dr. Streckeison, privat docent for geography in the University of Basel. — Dr. Tobler, privat docent for mineralogy in the University of Basel. — Dr. W. F. R. Weldon, of London, Lenacre professor of comparative anatomy in the University of Oxford, as successor to Professor E. Ray Lankester. — Dr. R. von Wettstein, professor of botany and director of the botanical gardens of the University of Vienna. — Jay Backus Woodworth, instructor in geology in Harvard University.

Deaths: Dr. Dareste de la Chavanne, the French anthropologist and teratologist. — Rev. William Colenso, a collector and student of New Zealand anthropology, February 10, aged 88. — John Collett, for several years state geologist of Indiana, at Indianapolis, March 15, aged 71. — Mr. Thomas Cook, teacher of anatomy, in London, February 8. — Alexandre Laboulbene, entomologist and pathologist, author of a *Faune Entomologique de France*, aged 73. — Dr. Franz Lang, teacher of natural history in the cantonal school of Solothurn, Switzerland, aged 78. — Dr. William Rutherford, professor of physiology in the University of Edinburgh, February 21, aged 60. — Dr. Carl Schönlein, assistant in the Zoölogical Station at Naples, aged 40. — Sir John Struthers, emeritus professor of anatomy in the University of Aberdeen, February 24, aged 75. — Gianpaolo Vlacovich, professor of anatomy at Padua, Italy.

Othniel Charles Marsh, professor of paleontology in Yale University, died March 18, 1898. He was born at Lockport, N. Y., Oct. 29, 1831, and was graduated from Yale College in the class of 1860. For two years after graduation he pursued studies in mineralogy in Yale, and then went abroad for three years of study in German universities. In 1866 he returned to Yale as professor of paleontology, a position he held until his death. Professor Marsh was never married and was without near relatives. His entire fortune was left by will to Yale University, aside from a bequest to the National Academy of Science of $10,000.

CORRESPONDENCE.

On the Use of the Terms "Heredity" and "Variability."

To the Editor of the American Naturalist:

Sir, — The necessity of an accurate terminology in the discussion of such an abstruse and complicated subject as the evolution philosophy has always been recognized. Every one is satisfied to have each writer coin as many new words, or to re-define as many old ones, as the discussion of his subject demands. And so we have numerous technical terms, as "germ-plasm," "idioplasm," "gemmule," "stirp," "id," "biophore," "diplogenesis," etc. It is, therefore, the more surprising to find so many really serious fallacies and disagreements creeping into evolutionary discussion through the equivocal use of such common terms as "heredity" and "variability."

These two words have been often, perhaps usually, regarded as antonyms. Heredity and variability have been treated as two diametrically opposing laws. Even when the opposition was not so much emphasized, they have been treated as two separate and sharply distinguished principles. Darwin treats them so. Weismann follows a similar usage, and, in general, the uncritical custom follows the same line. But this investment of the terms "heredity" and "variability" with two sharply contrasted meanings is essentially illogical. This is not a new discovery by any means, for it will be found on examination, I think, that the leading writers on evolution topics have shrunk, consciously or unconsciously, from bringing these terms into conflict at any critical point.

The beginning of the difficulty has been in the assumption that organic life began under the absolute dominion of the law of heredity. Later, according to this assumption, variability crept in, and the course of organic reproduction departed farther and farther from the rigid line of heredity. Bailey has controverted this assumption in his *Survival of the Unlike* by another equally gratuitous assumption. The law of heredity is said to be that like begets like; but Bailey asserts that, in the original and normal course of organic reproduction, "unlike begets unlike." Of course neither statement is absolutely true; but if both are properly qualified they acquire practically identical mean-

ings. What we actually know without contradiction is that like never begets absolute likeness, nor yet absolute unlikeness. It is, then, doing a violence to all our observation of nature to make the law "like begets like" mean absolute duplication of parent in offspring. It is not good English to make likeness mean identity, unless it be by special definition. Things are like which are similar. And if the old statement that "like begets like" is read to mean "similar begets similar," we have a statement of the obvious truth. And, moreover, there is no reason to suppose that the course of reproduction was ever different.

In this view of the case heredity and variability belong in the same scale. I have been in the habit of illustrating this relation by reference to heat and cold in the thermal scale. More cold means simply less heat. More variability means simply less rigid heredity. As the power of heredity wanes, variability waxes. And so, just as the physicist, for the sake of an accurate terminology, speaks only of heat, the biologist ought to have one general name for the one great law of reproduction. The term "heredity" would answer all purposes, had its proper meaning not already been clouded by the attachment of unwarranted definitions to it, and were its etymology not also a trifle awkward for the uses required. In fact we all speak of variability hundreds of times when we would speak of heredity, were it not for the convenient adjective "variable" with its easy comparisons. Partly to get away from false ideas of heredity, and partly to keep clear the unity of the reproductive law, I have adopted another word for use in my classes, and now speak of "the allophysical law." If the allophysical law were to be stated, it would be in the words "similar begets similar" ("like begets similar" would be more logical, no doubt; but it is easier to stick to the old order), or in the words "like begets like," properly explained.

If some one will give us a simple word to take the place of heredity and variability in their combined meaning, and one which shall be accompanied by some manageable and easily compared adjective, it will be a great convenience to future discussion.

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(The regular exchanges of the *American Naturalist* are not included.)

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